SWORN STATEMENT OF JOHN P. WIKSWO, JR., Ph.D

COUNTY OF DAVIDSON)
)
STATE OF TENNESSEE)

Affiant John P. Wikswo, Jr., swears as follows:

1. I hold a Bachelor's Degree in Physics from the University of Virginia, a Master's Degree in Physics from Stanford University, and a Ph.D. in Physics from Stanford University. I am the Founding Director of the Vanderbilt Institute for Integrative Biosystems Research and Education (VIIBRE), and at Vanderbilt University I am the Gordon A. Cain University Professor, A.B. Learned Professor of Living State Physics, and a Professor of Biomedical Engineering, Molecular Physiology & Biophysics, and Physics.

2. I began investigating and considering judicial electrocution protocols and electrocution equipment in 1992. I have continued to do so for the past twenty plus years.

3. The electrocution protocols and equipment I have reviewed during the past twenty plus years were designed to administer to a prisoner a 60 HZ alternating electrical voltage of between 1,500 and 2,500 volts and a current of 4 to 10 amps.

4. The electrocution protocols and equipment I reviewed accomplished this result by attaching to seated prisoners electrodes to the prisoners' heads and lower legs.

5. In the course of reviewing the electrocution protocols and equipment described above:

5.1. I reviewed scientific literature concerning the application of electrical current to living organisms.

5.2. I reviewed scientific literature describing the physiological trauma associated with lightning strikes, electrocution in industrial accidents, and electroconvulsive therapy.

5.3. I reviewed non-scientific material relating, among other things, anecdotal accounts from persons who have come into contact with a high voltage electrical current.

5.4. I reviewed autopsy reports of electrocuted prisoners.

5.5. I read statements from persons who witnessed judicial electrocutions of prisoners.

5.6. I conducted my own research.

6. After reviewing the electrocution protocols and equipment described above, I arrived at the following conclusions and opinions about them:

Attachment 34

6.1. Prisoners can remain alive for some period of time during the electrocution event. I base this conclusion on the following:

6.1.1. A prisoner's heart will not necessarily stop instantaneously when the high voltage electrical current contacts the prisoner's body.

6.1.2. Even when contact with high voltage electrical current causes a prisoner's heart to stop beating, when the current ceases there is a high probability that the prisoner's heart will resume beating.

6.1.3. While there is a possibility that a prisoner's heart will enter a mode of excitation known as fibrillation during an electrocution execution, when the current ceases the prisoner's heart can resume a normal beating pattern.

6.1.4. Even when a prisoner's heart fibrillates for an extended period of time during an electrocution execution, death does not occur instantaneously. Rather, death results over a period of time as the fibrillation of the prisoner's heart reduces cardiac output to the point that it is insufficient to maintain life.

6.1.5. When high voltage electrical current contacts a prisoner, the skeletal muscles he requires for breathing tetanize, and the prisoner cannot breathe to supply oxygen and eliminate carbon dioxide. Thus, a prisoner subjected to an electrocution execution described above dies from asphyxiation and/or organ damage due to thermal heating, i.e., cooking. These processes require a period of time to produce death.

6.1.6. No scientific evidence contradicts the above statements.

6.2. Prisoners can remain conscious and sensate for some period of time during the electrocution event. I base this conclusion on the following:

6.2.1. A prisoner will lose consciousness during an electrocution event through loss of brain function. Loss of brain function occurs through (1) a direct assault on the brain; or (2) insufficient blood circulation to the brain due to cardiac fibrillation or asphyxia.

6.2.2. Upon contacting the prisoner's body at the top of his head, the electrical current follows to the leg electrodes paths of least resistance. The prisoner's skull presents the current a resistance significantly greater than the resistance the prisoner's skin presents. As a result, the vast majority of the electrical current travels around the perimeter of the prisoner's head and down the prisoner's torso and legs until it leaves his body through the leg electrodes. As the current alternates, it follows like paths of least resistance in the opposite direction.

6.2.3. Because the skull effectively insulates the brain from the electrical current flowing from and to the head electrode/sponge, the electrical current does not immediately incapacitate the prisoner's brain. Rather, the ability of the prisoner's brain to function becomes

compromised over time by (1) the reduced portion of the current that reaches the prisoner's brain; (2) indirect thermal transfer through the skull; (3) indirect thermal transport through the blood vessels of the prisoner's neck; and (4) loss of oxygen.

6.2.4. While the reduced portion of electrical current that reaches the prisoner's brain may, on occasion, depolarize a prisoner's brain, there is no scientific evidence that the prisoner's depolarized brain neurons will thereafter be incapable of repolarizing during the alternating current stimulation.

6.2.5. Should depolarization of a prisoner's brain occur, a 60 HZ alternating current provides for repolarization of the prisoner's brain.

6.2.6. No scientific evidence contradicts the above statements.

6.3. Because prisoners can remain alive, conscious, and sensate during at least a portion of the duration of a judicial electrocution event, for the following reasons they can experience excruciating pain and suffering during the event:

6.3.1. When the high voltage electrical current contacts a prisoner and travels through his body it burns him, causing extreme pain.

6.3.2. When the high voltage electrical current contacts a prisoner and travels through his body it thermally heats, i.e., cooks, his body and internal organs, causing extreme pain.

6.3.3. When the high voltage electrical current contacts a prisoner and travels through his body it directly excites most if not all sensory, motor, secretory, and autonomic nerves along the paths the current follows, causing extreme pain.

6.3.4. When the high voltage electrical current contacts the prisoner and travels through his body it can excite some brain neurons, causing extreme pain as well as sensations of sound, light, dread, and fear.

6.3.5. When the high voltage electrical current contacts the prisoner and travels through his body, his skeletal flexor and extensor muscles simultaneously tetanize, causing extreme pain. The muscles will remain tetanized until the current ceases.

6.3.6. When the high voltage electrical current contacts the prisoner and travels through his body, the skeletal muscles he requires for breathing tetanize, and the prisoner can neither inhale nor exhale. As a result, the prisoner experiences the sensation of suffocating. The intense metabolic demands of muscle tetany aggravate the prisoner's sense that he is suffocating.

6.3.7. The prisoner's perception of time during the electrocution process can become distorted so that he may perceive (1) each of the sixty per second alternating cycles of

electrical current; and (2) the electrical trauma as lasting dramatically longer than it would appear to a bystander.

6.4. Because contact with high voltage electrical current causes muscle tetany, and because the electrocution protocols I reviewed command that the prisoner be harnessed tightly onto the electrocution equipment, during an electrocution execution a prisoner is unable to signal that he is experiencing pain and suffering.

6.5. Because of the unpredictability and variability of each prisoner's electrical resistance and that of the connections to his body during an electrocution execution, the current delivered to each prisoner will vary significantly from the currents delivered to other prisoners. As a result, the time individual prisoners remain alive, conscious, and sensate are unknown and will vary substantially from prisoner to prisoner.

6.6. Because prisoners can remain alive at the conclusion of an electrocution execution, the electrocution protocols I reviewed provided that after the executioner shuts off power to the electrocution equipment, a medical doctor wait for a period of time, usually four to five minutes, before the doctor examines a prisoner's body for signs of life. During this five minute period, prisoners who survive the electrocution process die from thermal heating, i.e., cooking, of their vital organs, and asphyxiation.

7. Attorneys working for the Office of the Federal Public Defender, Middle District of Tennessee, asked me to review:

7.1. a Tennessee Department of Correction document titled Execution Procedures For Electrocution (hereafter Tennessee Electrocution Protocol).

7.2. a 11/2/07 Report of Examination by County Medical Examiner concerning the September 12, 2007, judicial electrocution of Daryl Holton.

7.3. a 10/29/07 Autopsy Report concerning a post mortem examination of Holton's body.

7.4. a 10/30/07 Report of Microscopic Examination conducted as part of the Holton post mortem examination.

7.5. Color copies of photographs taken during the Holton post mortem examination.

7.6. Color copies of photographs taken concerning materials used in the Holton electrocution.

7.7. Color copies of photographs of clothing.

7.8. Color copies of photographs depicting the scene of the Holton electrocution after it was carried out.

7.9. Newspaper accounts of the events that occurred during the Holton electrocution.

8. Based on my review of the material described in Paragraph 7, above, and my consideration of that material in conjunction with the material described in Paragraph 5, above, I conclude and opine as follows:

8.1. The Tennessee Electrocution Protocol calls for (1) an initial twenty second application of a 1,750 volts, 7 amps, 60 HZ alternating electrical current; (2) a fifteen second "disengage" period; and (3) a fifteen second "re-engage" period again applying a 1,750 volts, 7 amps, 60 HZ alternating electrical current.

8.2. Tennessee's electrocution equipment requires the prisoner to sit in a chair. Electrodes are attached to the seated prisoner's head and lower legs, and cables connected to a high-voltage transformer deliver the stated voltage to the prisoner.

8.3. The initial twenty second application of electrical current will not provide a time long enough for a prisoner to die because (1) electrical current applied during an electrocution execution will not necessarily stop the prisoner's heart; and (2) the skeletal muscles the prisoner requires for respiration will relax when the current stops, and air will flow into the prisoner's lungs. During the fifteen second "disengage" period, a prisoner's heart can circulate the newly oxygenated blood to the brain and the rest of the prisoner's body, keeping him alive, possibly conscious, and possibly sensate for the second application of electrical current.

8.4. Because Tennessee's Electrocution Protocol and electrocution equipment is consistent with the electrocution protocols and equipment I previously reviewed, my conclusions and opinions expressed in Paragraph 6, above, apply to the Tennessee protocol and equipment. Specifically, prisoners executed using Tennessee's Electrocution Protocol and electrocution equipment can, for some period of time, remain alive, conscious, and sensate during the electrocution event and can experience the excruciating pain and suffering associated with the phenomena that occur when a high voltage electrical current contacts a human being.

8.5. A review of newspaper accounts of the Daryl Holton electrocution and documents and photographs created during the post mortem examination of Daryl Holton's body confirm my conclusion and opinion that (1) prisoners electrocuted using the Tennessee Electrocution Protocol and Tennessee's electrocution equipment can remain alive, conscious, and sensate for some period of time during the electrocution process; and (2) as a result can experience excruciating pain and suffering during that process. Specifically:

8.5.1. The Autopsy Report describes burns "above and behind the left ear, above the right ear, the right side of the forehead," and "the anterior and posterior aspects of both calve." These burns, shown clearly in the autopsy photographs, are consistent with the thermal heating that occurs as the electrical current passes between the electrodes and the prisoner.

8.5.2. The Autopsy Report describes thermal burns on the anterior and posterior portions of the neck. These burns, evident in the corresponding autopsy photographs, are consistent with a substantial electric current flow through the skin and soft tissues of the neck, which in turn would have been a result of the electrical insulating properties of the bones of the skull that would have prevented substantial current from passing through the brain and the spinal cord.

8.5.3. A narrow line of burns on the anterior neck evident in autopsy photographs is consistent with the collar of the shirt being wet from the saline applied to the scalp electrodes, and thus allowing a high current to flow superficially between the skin and the wet cloth, again consistent with a large portion of the current being carried by the skin and soft tissues of the neck.

8.5.4. The Autopsy Report describes thermal burns to the hands. These burns suggest that the electric current found an alternative path between the head and calf electrodes.

8.5.5. The Autopsy Report describes burns to the lower back and the right thigh. These burns are consistent with the electrical current flowing through these regions, and the absence of symmetrical burns to the left thigh indicates that there can be substantial differences in the current distribution within each leg.

8.5.6. The Autopsy Report describes burns on the left popliteal fossa. These burns are consistent with electric current flowing preferentially through the soft tissues behind the knee instead of through the insulating bone structures within the knee.

8.5.7. The burns shown in the autopsy photographs were substantially more severe and hence much more painful than what might be encountered with a "severe sunburn."

8.5.8. The Autopsy Report describes superficial blunt force injuries and abrasions to the scalp, forehead, chin, foot, upper arms, and calf. These injuries are consistent with the witness reports of the prisoner jerking against the straps and electrodes after application of the electric current and the resulting muscle contraction and tetany.

8.5.9. There was no report of discoloration of the dura underneath the head electrode, reported in other executions by electrocution. The lack of such a description is consistent with the current flowing in the scalp and any underlying soft tissue rather than penetrating the skull, which is relatively insulating as compared to the scalp and underlying soft tissues.

8.6. A review of the Tennessee Electrocution Protocol reveals a number of scientific and technical issues. Specifically:

8.6.1. The Tennessee Electrocution Protocol indicates on page 19 that the physician should "examine the body for vital signs five minutes after the electrical current ceases." There is no rationale provided for the specification of that time interval. It is likely that were the prisoner's heart still beating after the termination of the last application of voltage, then the prisoner would die from asphyxiation during that interval, thereby leading to cessation of the heartbeat well after the termination of the applied voltage. Body heating during electrocution would not be so great as to make it necessary to wait five minutes for the body to cool.

8.6.2. The Tennessee Electrocution Protocol states on page 34 that "While the electric chair is activated, the Facility Maintenance Supervisor and his assistant will assure that the designated voltage (1,750) and amps (7) are being delivered." Given that the electrical resistance of the prisoner is unknown prior to the electrocution procedure and may vary during that procedure it is impossible by the laws of physics in general and Ohm's law in particular, to guarantee that BOTH criteria stated on Page 34 and elsewhere in the Tennessee Electrocution Protocol of 1,750 volts AND 7 amps are met. There is no provision in either the Tennessee Electrocution Protocol or the design of the electric chair to ensure that both of these criteria can be met simultaneously, and hence I find the Tennessee Electrocution Protocol to be inaccurate from both the scientific and engineering perspective.

8.6.3. Furthermore, because of the series electrical resistance of the transformer wiring, cables, sponges and the contacts with the prisoner's skin, the voltage actually applied to the prisoner is somewhat less than the 1,750 volts that are delivered at the output of the open-circuit transformer. The current delivered to the prisoner will be actual applied voltage divided by the resistance of the prisoner, which is expected to change during the course of the electrocution as the skin burns, the water in the salt water is heated and then converted into steam, and the tissue under the skin potentially chars.

8.6.4. The requirement stated on page 42 of the Tennessee Electrocution Protocol that the exhaust fan must be turned on suggests the possibility of the generation of either smoke or fumes from burning human flesh during the execution process. The presence of a fire extinguisher (Page 67) suggests the possibility of an electrical fire, as has occurred during multiple judicial electrocutions.

8.6.5. There is no scientific basis for the requirement, stated on page 42 of the Tennessee Electrocution Protocol, that the electrocution cycle requires the delivery of 1750 V and 7 A for 20 seconds, with disengagement for 15 seconds, followed by re-engagement for 15 seconds.

9. Based on the foregoing, I conclude to a reasonable degree of scientific certainty that there is a substantial risk that a prisoner electrocuted using Tennessee's Electrocution Protocol and electrocution equipment will remain alive, conscious, and sensate for some period of time during the electrocution process and, as a result, will experience for some period of time the excruciating pain and suffering associated with the phenomena that occur when a high voltage electrical current contacts a human being.

FURTHER AFFIANT SAITH NAUGHT

John P. Wikswo, Jr., Ph.D.
Founding Director VIIBRE
Gordon A. Cain University Professor, A.B. Learned Professor of Living State Physics, Vanderbilt University
Professor of Biomedical Engineering, Molecular Physiology & Biophysics, and Physics, Vanderbilt University

STATE OF TENNESSEE

COUNTY OF DAVIDSON

Sworn and subscribed before me on this the 14th day of November, 2014.

NOTARY PUBLIC

My commission expires:

5/8/2017
Date

STATE OF TENNESSEE NOTARY PUBLIC
DAVIDSON COUNTY, TENN.
JANET Y. SANTANA

Attachment 34

DECLARATION OF JOHN P. WIKSWO, Ph.D.

I, John P. Wikswo, Ph.D., being of lawful age, declare the following:

Background and Experience

1. I am the Gordon A. Cain University Professor, the A.B. Learned Professor of Living State Physics, the Director of the Vanderbilt Institute for Integrative Biosystems Research and Education, and Professor of Biomedical Engineering, Molecular Physiology & Biophysics, at Vanderbilt University. As an experimental biophysicist, electrophysiologist, and biomedical engineer, much of my research throughout my career has been in the area of electromagnetic theory and experiment, and I have studied the production, measurement, modeling, and interpretation of the electric and magnetic fields produced by bioelectric current sources in conducting media. I have worked on the modeling and analysis of current distributions in biological tissue, with special emphasis on the biophysics of defibrillation, the electrical properties of nerves and cardiac muscle, and the recording of the electrical potentials produced by the brain. I have authored over 130 referred scientific publications, 22 book chapters and review articles, hold 11 U.S. patents, and have published 108 papers in the proceedings of various national and international conferences. In the past thirty years, I have presented over 150 invited talks and colloquia on my research. I have conducted numerous electrical experiments on earthworms, frogs, rats, rabbits, dogs, and humans. My complete *curriculum vitae* is attached to this report. I have studied in depth and contributed to the literature describing the interactions of electric fields with biological tissue.

2. I have reviewed the literature describing the physiological trauma associated with lightning, electrocution in industrial and other accidents, and electroconvulsive therapy. I have read descriptions of the methods by which execution by electrocution is carried out in the United States. I am familiar with the historical development of electrocution as a means of execution in

the United States. I have reviewed the autopsy reports of forty (40) executions by electrocution in Alabama and Florida. I have read five affidavits by eyewitnesses to executions by electrocution. In the course of developing my opinions regarding the possibility of undue suffering caused by electrocution, I have reviewed numerous scientific and nonscientific materials in addition to my own research observations.

Summary of Findings

3. Based upon my personal research experience, detailed review of the literature, and review of the information previously described, I have reached the following conclusions regarding execution by electrocution:

a. Execution by electrocution is extremely painful, because of the direct stimulation of nerves and pain receptors, the direct and indirect contraction of virtually all of the skeletal muscles in the body, the contraction of intestinal and other smooth muscle, and the intense pain associated with electrical burns.
b. There is no scientific evidence suggesting that the intense electrical currents during execution by electrocution induce instantaneous anesthesia or analgesia, and/or unconsciousness. There is ample evidence from the medical literature on high-voltage (greater than 1,000 volts) electrical accidents that individuals can maintain consciousness during strong electrical shocks, even shocks to the head that produce severe tissue damage.
c. There is ample evidence, from judicial electrocutions, electrical accidents, and fibrillation research, that at the voltages utilized in judicial execution, the heart will not reliably enter into fibrillation and hence can remain capable of pumping blood through the body after the end of the electrical shock used in judicial electrocution
d. Death is caused primarily by suffocation due to paralysis of the respiratory muscles and respiratory arrest, and by thermal heating of the brain.
e. Death by electrocution is not instantaneous.
f. The minimum voltage and current and duration of this voltage and current required to execute a particular individual by electrocution are unknown, and will vary substantially from individual to individual.

Clarification of Electrical Terminology

4. There are a number of fundamental electrical and physiological principles that come to play during judicial electrocution. A clear understanding of these principles is needed to avoid confusion and misconceptions that are common in discussions of judicial electrocution. Hence, I will begin this report by developing an analogy that can be used to demonstrate the differences

between voltage and voltage gradient, current and current density, and resistance and resistivity. These six terms have clear definitions in the physics and engineering literature, but these definitions may not be particularly useful to individuals not trained in either field.

g. Voltage, V, is defined as the amount of electrical energy that is delivered to a positive charge of one coulomb as it is moved between two points in space. (It takes 625,000,000,000,000,000 electrons to make a coulomb). Voltage is also known as electrical potential, and has units of volts. An analogous quantity to voltage is the height of a hill above a level plane. When a spherical ball is pushed or pulled to the top of a hill, it is given mechanical potential energy that can later be recovered as mechanical kinetic energy when the ball is allowed to roll down the hill. When an electron is pushed or pulled to the top of an electrical "hill" by a battery or generator, it is given electrical potential energy that can then be recovered when the electron is allowed to flow down the electrical hill. Hence the higher the hill, the greater is the mechanical energy that the ball can deliver when released, and correspondingly, electrons at a high electrical voltage (or potential) can deliver more electrical energy than can electrons at a low voltage (or electrical potential). Voltage drop is a commonly used term to describe the difference in voltage between two points in a circuit. Voltage drop is frequently used to describe the loss of electrical energy (and its conversion into heat) as current passes through a resistor, since the voltage is higher on one side of the resistor than on the other.

h. If a ball is allowed to roll down a hill, it will accelerate and move faster and faster as it goes down the hill, as the mechanical potential energy is converted to mechanical kinetic energy. The velocity of the ball will increase until the force of gravity that accelerates the ball is balanced by the force of friction between the ball and the hillside, and the force of air resistance, *i.e.*, the ball will achieve a terminal velocity. Electrons in metals and ions in saline media and tissue also achieve a terminal velocity. While the electrons and ions experience continual accelerations, they also bump into stationary ions, atoms, or impurities that cause them to stop repeatedly. When the electron or ion is stopped, the kinetic energy it has acquired is converted into heat. It is just as if the ball was rolled down a hill with a number of trees or bushes -- just as the ball starts rolling, it bumps into a tree and is stopped, whereupon it begins rolling downhill again. In such a situation, the overall height of the hill is not as important to the ball as is the slope of the hill at the point where the ball is located at the moment, *i.e.*, the vertical drop divided by the horizontal distance traveled. If the slope of the hill is steep, the ball will begin to roll quickly after it hits a tree, and if the hill is gentle, the ball will start to roll slowly. The electrical analogy of the slope of the hill is the voltage gradient, ∇V, *i.e.*, voltage drop divided by the distance. For our discussion, voltage gradient is the same as the electrical field, E, and has units of volts per meter. When you are standing on the side of a hill, it is important to distinguish between the height of the hill and its slope, since the slope will determine how hard it is for you to remain on the hillside without sliding down. Similarly, it is important to distinguish between voltage and voltage gradient. The voltage between the head and the foot in judicial electrocution must not be confused with the voltage gradient in a particular organ, which will determine how quickly ions move through that organ.

It is important to distinguish between voltage and voltage gradient. In our analogy, a shelf-like rock outcrop jutting horizontally from the hill could be at a high altitude, and yet be level. Since it had no slope, a ball placed on this outcrop would not roll. A conducting object can be at a high voltage, yet no current will flow because there is no local voltage gradient. If the arms of the prisoner are not in contact with any grounded metal, then they will be at a high voltage over their entire length, but no current will flow along the arm (except for small capacitive charging currents).

i. Now let us suppose that the hill we are discussing is in fact a kilometer-long ridge running from north to south, and the elevation of the very top of the ridge is constant, say 1000 meters. People are placed every meter along this ridge, and each is given a supply of balls. Halfway down the eastern side of the ridge is a row of people, also one meter apart, placed along the 500 meter contour to count the balls as they roll past. Each person on the ridge releases balls at a steady rate onto the eastern slope of the hill. If 1000 balls are released from the ridge every second, eventually, 1000 balls per second will pass the observers midway down the ridge. This rate of 1000 balls per second is the equivalent of electrical current, I, which is the amount of electrical charge in coulombs per second that passes a point in a circuit every second. Electric current has units of amperes, which is the same as coulombs per second. Electrical current is a global measure of the rate of flow of electrical charge across the width of the circuit or the cross-sectional area of a wire or larger conductor. Resistance is a global property of the entire conducting object for a particular distribution (pattern) of current flow.

j. From the perspective of a single tree which is being pelted by balls, the total rate at which balls roll down the entire hillside is not as important as the rate at which balls are rolling past that particular tree. If a tree happens to be at the end of a ravine that collects balls released by a number of different people, then the tree will be hit by substantially more balls than would a tree on a small knoll that deflects the balls to either side. In an extended conductor, such as the human body during judicial electrocution, the total current delivered is generally not as significant as the current density, J, *i.e.*, the amperes per square meter. If an electrically sensitive organ is located in a constriction in the body such as the neck, the current density will be higher there than it would be in the chest because the same total current has the more restricted area of the neck across which it can flow.

k. Now that we have described voltage and voltage gradient, and current and current density, we can examine their relationship. In our hillside analogy, the trees slow the balls down, *i.e.*, the trees provide a mechanical resistance. With electricity, there is also a resistance, R, which limits the amount of current that flows for a given voltage. Resistance is measured in ohms, which are equivalent to amperes per volt. In the hill analogy, the "resistance" of the hill is determined by the total number of trees on the entire hillside. In electricity, the current I, the voltage V and the resistance R are related by Ohm's law: $\mathbf{V} = \mathbf{I} \times \mathbf{R}$. For us, Ohm's law is more useful when rewritten as $\mathbf{I} = \mathbf{V} / \mathbf{R}$,

or the current flowing along a conductor is equal to the voltage applied to the conductor divided by the total resistance of the conductor.

l. From the point of view of a small grove of trees on the hillside, the total number of balls being released at the top of the ridge, the height of the ridge, and the total number of trees is less important than the local environment, *i.e.*, the number of balls passing the grove, the slope of the hillside, and how tightly clumped is the grove (the tree density). Electrically, the tree density becomes the resistivity, ρ, which is measured in ohm-meters. Ohm's law can then be written as a local property of the conductor, $\mathbf{J} = 1/\rho\, \nabla V = \mathbf{E}/\rho$. The electrical current density at a point in the circuit is determined by the voltage gradient ∇V (or electric field **E**) divided by the resistivity. Resistivity is a microscopic property of the material through which the current flows. In a heterogeneous object, different regions can have different resistivities.

m. When the balls crash into a tree and are temporarily stopped, they deliver kinetic energy to the tree and can bend or even damage the tree. Similarly, when electrons or ions are transiently stopped by whatever causes the resistance in a material, they too transfer their kinetic energy to whatever stopped them. In materials that are electrically resistive, the kinetic energy is transformed into heat. Electrical power, **P**, is the time rate at which electrical energy is converted into heat. Power is measured in watts. Since power is the current times the voltage, $\mathbf{P} = \mathbf{I} \times \mathbf{V}$, one watt is the same as one volt-ampere. By applying Ohm's law to the definition of power, the equation can be written in either of three ways: $\mathbf{P} = \mathbf{I} \times \mathbf{V} = \mathbf{I}^2 \times \mathbf{R} = \mathbf{V}^2 / \mathbf{R}$. Power is a global measure, applicable to the entire conductor. Locally, there is an equivalent measure, power density, **p**, measured in watts per cubic meter, that is the product of the local current density and the local electric field, *i.e.*, $\mathbf{p} = \mathbf{J} \times \mathbf{E}$. Again, we can use Ohm's law to write this as $\mathbf{p} = \mathbf{J} \times \mathbf{E} = \mathbf{J}^2 \times \rho = \mathbf{E}^2 / \rho$.

n. One way to see the relationship between the local, or microscopic, properties of a conducting material and the global, or macroscopic properties of the entire conducting object is with the example of a bar of conductor that is of length ℓ, width w, and height h. It is an implicit assumption of this simple model that the current flows only parallel to the longitudinal axis of the bar, and is uniform over the cross-sectional area defined by the rectangle of sides w and h. If a voltage V is applied to one end of the bar and the other end is grounded (zero voltage), then the electric field in the bar is $E = V/\ell$. The current in the bar is measured to be I, so that the current density is the current divided by the cross-sectional area, A, or $J = I/(w \times h) = I/A$. It follows from this and both the local and global forms of Ohm's law that $R = \rho \times \ell / A$. The longer the conducting bar, the higher is its resistance because there is more material that all of the current must pass through; the larger its cross-sectional area (width, w, times height, h), the lower is its resistance because the current can spread out and move along the bar in parallel. Bone has a higher resistivity than muscle, and hence a block of bone will have a higher resistance than would an identically shaped block of muscle.

This equation is valid only for conductors whose cross-sectional areas are the same over their entire length, and as such this is essentially a one-dimensional equation. It does not apply to conductors for which the current can either disappear from the side of the conductor anywhere along its length or travel the entire length of the conductor and

leave from the end. It does not consider electrical anisotropy, as has been found in skeletal and cardiac muscle and certain neural tissues. It is not valid for three-dimensional situations, for example when the current leaves the head electrode, spreads out through the sponge, and then enters the scalp and either travels along the scalp or passes through the scalp into the brain. It does not include the effects of voltage gradients within the brain on the current distribution through the skull. Calculus can be used to derive the resistance of certain two- and three-dimensional conducting geometries that are slightly more complicated than the simple bar yet exhibit simplifying symmetries, in that the stated formula is applied differentially and then integrated analytically, but it has not been demonstrated that this approach can be used with any degree of accuracy for the geometry appropriate for judicial electrocution. To simply insert selected scalp and skull dimensions and resistivities into this formula constitutes a grave oversimplification that will lead to substantial errors. The distribution of currents within the scalp, skull, cerebral spinal fluid, and brain can be determined accurately only using three-dimensional numerical models or laboratory experiments on heads or head phantoms.

o. In electrical circuits, such as a piece of wire, the current that enters one end of the wire must be identical to the amount of current that flows out the other end. If there are different parts to a circuit that are connected in series, such as the wire connecting the power source to the head-piece, the sponge between the head electrode and the person, the head, the neck, the chest, the abdomen, the leg, the sponge at the leg electrode, and the wire connecting the leg electrode to the power source, then the current flowing in series through each part must be the same. However, there will be a voltage drop associated with each segment of the circuit, as determined by the resistance of each segment. The sum of these voltage drops will have to equal the voltage applied by the power source.

p. If the current can pass through a circuit by more than one path, *i.e.*, there are parallel current paths, then the voltage applied to each path will be the same but the current flowing in each path will be determined by the relative resistance of each parallel path. The lower resistance path will carry a proportionally higher current. The sum of the currents through the parallel paths must equal the total current flowing in the circuit.

q. It is important to realize that while the current and voltage gradient in a local region obey Ohm's law, in that their relative values are determined by the local resistivity, their absolute values are determined by the distribution of current and voltage over the whole object. In our analogy, the number of balls rolling through the small grove in mid-hillside is determined by the shape of the hill above it, since the presence of a bluff or a ravine far above will affect the current density at the grove. For this reason, the determination of the voltage and current distributions in a complicated conductor, such as the human body, is difficult to determine from simple calculations. As an example, the total current flowing through the head during judicial electrocution must equal the current delivered by the power source, but the distribution of current within the head is determined by a complex combination of series and parallel circuits: some of the current will flow through the scalp; A parallel path consists of the series resistance of the skull and the contents of the skull, which in turn is described by the parallel combination of cerebral spinal fluid, white matter, and grey matter. The electric fields in each region will be affected not only by the resistivity of that particular region, but also by the properties of all of the surrounding conducting material and alternative parallel paths for the current.

r. The distribution of current and voltage in a volume conductor (as opposed to a thin wire) is determined by both the locations where the current and voltage are applied, and by the combined effects of the shape of the conductor and its distribution of resistivity. In volume conductors, it is overly simplistic to state that current follows the shortest path or the path of least resistance. The distribution of current and voltage must obey the equations that govern electric and magnetic fields, known as Maxwell's equations. In certain cases, these equations reduce to Laplace's or Poisson's equation. Their solution is frequently written as a Freldholm equation of the second kind, in which the voltage is given by an integral that also contains the voltage. Solution of this type of equation is difficult, since the voltage and current at one point is determined by the voltage and current at every other point, and to know one voltage and current, it is necessary to know all voltages and currents. In general, solution of these equations is done numerically, and shows that currents spread over the entire conducting object, with currents generally higher in regions of lower resistivity, but with strong geometrical effects.

s. Electrical capacitance, measured in farads or coulombs per volt, is the ability of an object to store charge. In our analogy, it is the equivalent of the ability of the rock outcrop to store balls. In judicial electrocution, the capacitive effects should in general be smaller than the resistive ones, although no measurements of capacitance during judicial electrocution have been reported.

Scalp-Electrode Interface and Burns

5. The electrical resistance of the skin will be expected to drop quickly after the voltage is applied to the prisoner. As stated by J.P. Reilly in his book Electrical Stimulation and Electropathology, "at the level of electric line voltages, *i.e.*, 110 to 220 volts, a skin impedance breakdown occurs fairly rapidly. ... For example, 50-Hz AC voltage stimulation results in an initial rapid drop in impedance within a fraction of a minute, followed by a slower drop in the

first minute, and then more gradual decreases in the next 7 to 8 minutes until a plateau is reached." The net result is that for a given applied voltage, there will be an rapid increase in the current delivered to the prisoner as the skin resistance breaks down. However, if the moisture is driven from the sponge or gauze, or a significant charring occurs, the resistance might increase.

6. In execution by electrocution, electric voltage is applied to the head of the prisoner by a metal scalp electrode, with a saline-filled sponge or gauze between the metal and the scalp. In comparison to the electrical conductivity of human flesh, the interface between this electrode/sponge and the scalp presents a region of very high electrical resistance. As a result, a substantial fraction of the electrical power dissipated during electrocution is in fact dissipated at the electrode-scalp interface and in the scalp tissue immediately adjacent to the electrode. Initially, there will be a decrease in resistance as the insulating layers of skin are burned away. As a result of the power dissipation at the electrode-tissue interface, there will be heating, which will lead to severe burns and vaporization of the saline in the electrode and also tissue fluids. The evaporation of the water in the saline-filled sponge, the effect of vapors released at the interface, and the formation of char may cause the electrode-tissue interface resistance to increase with time, thereby reducing the current delivered by the circuit. Other factors may counter this effect, including the electroporation of cell membranes in the tissue underneath the electrode.

7. The concentration of electric current as it leaves the electrode will cause severe burning of the scalp, as reported in all of the forty (40) autopsy reports reviewed. Because the metal electrode and saline-soaked sponge or gauze beneath it will approximate an electrical isopotential, the gradients in the potential and hence the current flow resulting from these gradients will be concentrated in an annular region of the scalp at the periphery of the electrode. This concentration of current will be exacerbated by the presence of the thin, high-conductivity

scalp, and the insulating bones of the skull beneath it. Hence much of the current passing through the electrode into the body will have to pass through this annular ring of tissue. As a result, there is often an annular burn on the top of the head, as reported in 33 of the 40 (82%) autopsy reports reviewed (Wayne Eugene Ritter, Michael Lindsey, Wallace Norrell Thomas, Robert Henderson, Nollie Lee Martin, Robert Marion Francis, Robert Allen Harich, Raymond Robert Clark, James William Hamblen, Anthony Bertolotti, Aubrey Adams, Theodore Robert Bundy, Jeffery Joseph Daugherty, Willie Jasper Darden, Jr., Beauford White, Ronald John Michael Straight, David Livingston Funchess, Daniel M. Thomas, Michael Durocher, Larry Joe Johnson, Marvin Francois, Johnny Paul Witt, James David Raulerson, Thimothy Palmes, James Duprey Henry, Ernest John Dobbert, David Leroy Washington, Carl Elson Shriner, Richard Lewis Adams, Arthur F. Goode, III, Anthony Antone, Robert Sullivan, Pedro Luis Medina). It would be expected that this burn ring would involve the entire thickness of the scalp; after the burn progresses through the skin and whatever thin muscle layer is present, it will reach the insulating layer of subcutaneous fat, which would then melt, vaporize and burn. The result would be a layer of char outside of the bones of the skull.

8. The burn ring on the crown of the head and the third degree burn within the burn ring has been proposed as evidence that the path of the electricity is through the top of the skull into the brain. This is not correct. In some electric chairs, the metal electrode is smaller than the sponge, so the current spreads out from the electrode into the sponge. To the extent that there is current flow in the sponge parallel to the surface of the head, there will be a corresponding voltage gradient along the sponge/head interface. Let us first assume that the skull beneath the scalp is a perfect insulator, so that the current could not enter the skull. The magnitude of the tangential current in the scalp beneath the sponge will depend upon the relative resistivity of the sponge and the scalp. The current density flowing tangentially along the scalp will be zero at the center

of the sponge, and will grow with distance from the center as more and more current enters the scalp from the sponge. At the edge of the sponge, the current flowing from the electrode and through the sponge can only flow into the scalp, and as a result, the total current delivered to the electrode from the power source must pass through the annulus of scalp just outside the sponge. The current density at that point is the total current divided by the product of the circumference of this region and the scalp thickness. Further from the edge of the sponge, the circumference that must be crossed by the current increases roughly in proportion to the distance from the center of the sponge. As a result of the geometric spreading of the current beyond the sponge, the current density in the scalp is reduced with distance from the sponge. Because of the increase of current density from the center of the sponge towards the edge, and the reduction beyond the edge, the very highest current densities will occur in the scalp in the annular region immediately beneath the edge of the sponge. This is the region where the most severe thermal effects will occur.

9. Were the skull a better conductor than the scalp, the current density would be more uniform beneath the electrode, and as a result the burn would be more uniform beneath the sponge. The severely burned region would be more like a disk than a ring. Obviously, the skull is neither a perfect insulator or a perfect conductor, but the presence of the burn ring indicates that a substantial fraction of the current passes from the sponge into the scalp and spreads outward into the adjoining scalp, rather than crossing the scalp and passing across the skull and into the brain.

10. The presence of a burn ring is a well known phenomenon in the literature describing cardiac defibrillation electrodes and is not evidence of current passing directly and uniformly into the tissue deep beneath the electrode.

For a given voltage, V, applied to the prisoner, the current, I, that will flow through the prisoner will be equal to the voltage divided by the total resistance, R, between the two electrodes, *i.e.*, Ohm's Law $I = V/R$. The resistance as seen by the power supply is the sum of the resistance of the cables, the electrodes, and the interelectrode resistance. The interelectrode resistance is in turn determined by the resistance of the saline sponges or gauze between the metal electrodes and the tissue, the geometrical shape and size of the electrodes, the conductivity of the skin beneath the electrodes, the presence of muscle or bone beneath that skin, and the appropriately-weighted electrical conductivities of all tissues between the two electrodes. The total electrical resistance will vary during the course of the shock, as the skin is heated and the electrically insulating skin layers are perforated, as the saline in the sponge or gauze beneath the electrodes vaporizes, and as the intervening tissue is heated, vaporized, and possibly charred. However, at no point in time is it possible for the electric chair power supply to control both the current and the voltage applied to the prisoner. If one is set, the other follows directly from Ohm's law. If the saline-filled sponge or gauze beneath the electrodes has any appreciable resistance, as might occur as the water vaporizes, substantial voltage drops may occur within the sponge or gauze, thereby further reducing the voltage actually applied to the prisoner. If the electric chair power supply is incapable of providing the current that equals the applied voltage divided by the resistance of the electrodes and the prisoner's body, the actual voltage applied to the prisoner will be reduced automatically, or the power supply will be destroyed, or a fuse or circuit breaker will disconnect the electricity. Unless the current and voltage are both measured, it is impossible to state exactly what voltage was actually applied to the body. Because of the electrode resistance effects described above, accurate measurement of the voltage actually applied to the prisoner would require the use of independent electrodes connected to the head and leg.

11. When current is applied to the prisoner, there will be a voltage drop across the sponges that connect the electrodes to the person being electrocuted. If the resistivity of these sponges is high, they will not only dissipate power, but they will also limit the amount of current that is delivered to the prisoner. Some of the applied voltage would be dropped across the sponges, rather than across the prisoner. A proper determination of the voltage actually applied to the prisoner would require the use of separate electrodes, that do not carry any current, to measure the voltage applied to the prisoner. A chart recorder measuring the voltage delivered by the power source does not indicate how much of that voltage drop appears across the wires, across the connections to the electrodes, the sponges, or the prisoner. It is accepted practice in physics and electrical engineering to use one pair of wires to deliver the current and another to measure the voltage applied to the test object. Otherwise, there can be substantial errors in determining what voltage is applied to the object.

12. It is incorrect to assume that the application of 1,800 - 2,200 volts between the head and the leg electrodes of a prisoner during judicial electrocution will produce larger physiological effects to the brain than would the application of 150 volts during electroconvulsive therapy. While the voltage drop across the entire prisoner's body may be 1,000 volts or higher, depending upon the voltage drop within the sponges, the voltage drops across just the head during judicial electrocution will be smaller, since voltage drops will also occur elsewhere in the body, particularly at restrictions such as the neck and knee. The voltage drops across the head or within the brain during judicial electrocution are unknown. Furthermore, the experience with electroconvulsive therapy indicates that the physiological effects of electrical current will be strongly dependent upon the actual path taken by the electrical current within the brain. The path of electrical current within the brain during judicial electrocution is unknown.

13. It has been stated that electrode gel is used during judicial electrocutions to reduce the amount of post-mortem burning. Electrode gel is used in the recording of bioelectric signals such as the electrocardiogram (ECG) and the electroencephalogram (EEG) to reduce skin resistance. Some gels contain abrasive material, so that when rubbed in the skin, the resistive layer is perforated. While such electrode paste may reduce the initial resistance of the skin when the electric current is first applied, at the current densities used in judicial electrocution the resistivity of the skin is rapidly broken down. Burning is a result of the power being dissipated throughout the circuit: in the sponges, in the skin, in the subdermal layers, and the underlying tissue. There is no evidence that this electrode paste reduces post-mortem burning. Since the initial resistance of the skin could be reduced by the paste, it would be better to state that the paste reduces ante-mortem burning, but even this is unproven. Given the complexities of the thermal response of tissue to electrical current and the difficulties associated with determining the time of death, or even of loss of consciousness, it is impossible to state whether the electrode paste reduces post-mortem burning. Given the charring of the skin in the burn ring and the third-degree burn within the ring, the role if any of the electrode paste is unclear.

Insulating Properties of the Skull

14. The ability of tissue to carry electric current is determined by its electrical resistivity. When a voltage is applied to a conducting object, the magnitude of the resulting current that flows through the object is inversely proportional to the resistivity. In complex, heterogeneous conducting structures, such as the human body, the flow of current is determined not only by the resistivity of the various regions, but also by their shape. Wherever low resistivity pathways are available, the current will be shunted away from adjacent high-resistivity ones. Because the low-resistivity brain (approximately 2.2 Ωm) is separated from low resistivity scalp (approximately 2.2 Ωm) by means of the highly resistive bones of the skull (approximately 176

Ωm), the majority of the electric current delivered to the body from the scalp electrode will flow along the scalp and superficial cranial muscles, rather than directly entering the brain. The exact amount of this shielding effect is unknown. Reports in the electroconvulsive therapy literature indicate that between 80% and 98% of the current applied to the head is shunted by the scalp, so that only 2% to 20% of the current is delivered to the brain. This shielding from the brain of the externally-applied electrical current, caused by the conducting properties of the scalp acting in concert with the insulating properties of the skull, is the identical effect that causes significant attenuation of the electrical signals from the brain as recorded on the surface of the scalp during electroencephalography. The reported differences in the amplitude of EEG signals recorded from the scalp and the exposed cortical surface are consistent with this shielding effect.

15. Because of the longitudinal flow of current from the top of the head through the neck, there could be fraction of an ampere of total current flowing through the brain. However, because of the much larger cross-sectional area of the brain, the current densities in the brain will be much lower than those in the scalp.

16. Because tissue is resistive, electric power will be dissipated in the form of heat when current flows through the tissue. For a given current, more power will be dissipated the more resistive is the tissue. However the dissipation in a particular tissue will be determined in part by whether there is an alternative, parallel path for the current to follow. Hence the power dissipation in the brain is determined by how much of the current passes through the skull into the brain versus being shunted around the skull by the scalp; one would expect the power dissipation in watts per cubic meter to be a factor of one hundred lower in the brain than in the scalp. Similarly, because the resistivity of the lungs is a factor of three greater than the surrounding tissue, the current will be shunted away from the lungs, to be carried primarily by the thoracic muscles.

17. It is well recognized that direct electrical stimulation of the brain via scalp electrodes is extremely painful. It is difficult to apply sufficient current density to the scalp to have any neurological effect on the brain without causing intense scalp pain, in part because of the aforementioned insulating properties of the skull. For this reason, external electrical stimulation of the brain is seldom used clinically, except for electroconvulsive therapy, which requires the use of general anesthesia, muscle relaxants (to prevent broken bones), and anticholinergic agents (which control cardiac bradycardia and tachycardia).

18. Because trans-scalp electrical stimulation of the brain is so painful, a number of firms have developed magnetic stimulators, which allow currents to be induced in the brain while not being induced in the scalp, thereby allowing clinical neurophysiologists to study efferent neural pathways that control motor functions in humans. Because of the conducting properties of the scalp and the insulating properties of the skull, these studies previously could only be conducted when the surface of the brain was surgically exposed for direct application of current to the brain tissue. Based on this analysis, I conclude that the electrical currents delivered to the brain during electrocution have significantly smaller electrophysiological effects than the currents that are simultaneously delivered to the skeletal muscle and peripheral nerves that lie directly in the path of the applied currents flowing from the top of the head, across the scalp, and down the body to the legs.

19. The ability of the scalp to shunt current away from the brain is confirmed by the generally mild thermal injuries to the brain, in contrast to the massive thermal damage to the scalp. In 10 of the 40 (25%) autopsy reports from executions by electrocution, epidural hematoma was reported (Beauford White, David Livingston Funchness, Daniel M. Thomas, Michael Durocher, Larry Joe Johnson, Marvin Francois, Thimothy Palmes, Carl Elson Shriner, Arthur F. Goode, III, Robert Sullivan), some of which were reported as being due to heat.

Discoloration of the dura was reported in 16 of the 40 (40%) of the autopsies from execution by electrocution. (John Louis Evans, Robert Marion Francis, Roy Allen Harich, Anthoni Bertolotti, Aubry Adams, Theodore Robert Bundy, Jeffrey Joseph Daugherty, Willie Jasper Darden, Jr., Michael Durocher, Larry Joe Johnson, Johnny Paul Witt, Timothy Palmes, James Dupree Henry, David Washington, Arthur F. Goode, III). In many of the autopsy reports, it was indicated that cuts through the brain and upper cervical spinal cord revealed no other abnormalities. Hence it is apparent that the brain is not being burned directly because of the electrical and thermal resistance of the skull. However, the ability of the brain to function is compromised as it is heated indirectly by thermal transfer through the skull and thermal transport through the blood vessels of the neck.

20. It is well-established that the electrical resistances of human tissues vary widely from individual to individual. Furthermore, there are a number of compounding factors that affect most critically the electrode/tissue resistance, including the presence or absence of fatty tissue beneath the skin, the distribution and activity of sweat glands, the amount of oil in and on the skin, hair, skin thickness, skull thickness, skull resistance, location and size of cranial fissures (sutures) in the skull, regional blood flow at the time of electrocution, the geometry of the stimulating electrodes, and the preparation of the skin surfaces prior to the application of the electrodes. The well-documented presence of severe burns under the electrodes indicates that the current-carrying capacity of tissue is greatly exceeded and that thermal mechanisms of energy dissipation (i.e., burning of tissue) become dominant.

21. The distribution of currents in the brain as a result of electrical stimulation applied to the scalp is a complicated problem, in that it is necessary to include the effects of the scalp, the skull, the openings in the skull, the cerebral-spinal fluid, the cortex, the grey matter, the blood vessels, and the ventricles within the brain. Because of the complex and varied shape of cortical neurons

and their electrical connections, the electrical properties of white matter can in general be treated as being directionally independent (isotropic), but within the grey matter, the direction of the current flow has been shown to reflect the direction of the nerve fibers, so that the grey matter is more properly described in terms of a directionally dependent (anisotropic) electrical resistivity.

<u>**Anesthesia or Loss of Consciousness**</u>

22. There is no documented evidence that large electrical shocks such as occur in execution by electrocution induce anesthesia. It is well-recognized that the primary effect of electrical shock is stimulation of muscle contraction and severe third- and fourth-degree burns at the point of electrode contact. In execution by electrocution, the electrodes are on the scalp and the legs, locations where there are ample nerve endings to transmit excruciating pain signals to the subject's brain.

23. It has been stated that the brain loses consciousness immediately after application of the electric current, or within milliseconds. There is no scientific or evidentiary basis for this claim. It has been hypothesized that the application of current leads to instantaneous and massive depolarization of the brain that results in instantaneous unconsciousness. Reports in the scientific and medical literature, as well as anecdotal reports from neurologists treating victims of electrical shock, indicate that it is possible to maintain consciousness during high voltage electric shock.

24. In electroconvulsive therapy, the electroencephalogram (EEG) is frequently measured during and after the procedure. No such measurements have been made during judicial electrocution, and hence it is scientifically impossible to determine whether or not the brain is functioning following the first application of electric current. The reports in the literature of individuals who have survived accidental electrical shock to the head indicate that the scientific evidence is to the contrary. In general, prisoners are non-responsive following the first

application of electric current, even though there may be a heart beat or other indications of life. Because of the lack of any information regarding the actual response of the brain during the course of the electrical current during judicial electrocution, it is unclear when in the course of the execution the brain becomes unresponsive. There is no scientific evidence to indicate that it occurs instantaneously.

25. It is incorrect to state that the loss of consciousness would result from the administration of just 40 milliamps of electricity to the heart and brain. There are no such distinct thresholds for either the heart or the brain. Much larger currents are experienced by victims who survive accidental electrical shock and lighting strikes.

26. It is incorrect to state that there is a widely accepted scientific opinion that judicial electrocution results in the massive and instantaneous depolarization of the brain with the initial surge of high voltage electricity. There is no such widely held opinion.

27. The response of a nerve cell to the application of an electrical current to the brain will depend upon a number of factors, including the shape and size of the nerve cell, its orientation relative to the applied electric field, and the uniformity of the applied field. The threshold for stimulation of a single nerve fiber can differ by a factor of 100, depending upon whether the electric field is parallel or transverse to the axis of the cell. The side or end of the cell that is closest to the negative electrode will be depolarized, while the opposite end or side will be hyperpolarized. The stimulation of certain cells will trigger the release of neurotransmitters at some synapses that will excite (depolarize) adjacent cells and at other synapses the release of neurotransmitters that will inhibit (hyperpolarize) other cells. When the direction of the current is reversed during a single cycle of AC current, the ends that were depolarized will be hyperpolarized, and vice versa. The extent to which the cells can track these reversals of current will be determined by the kinetics of the individual ion channels in the membrane of that cell.

The electrical shocks used in electroconvulsive therapy are designed by their strength, duration, and electrode location to induce grand mal seizures in the form of cyclic excitation and inhibition of populations of neurons; these seizures are NOT in any way a massive depolarization of the entire brain.

28. There is no scientific evidence that a voltage in excess of 1,800- 2,000 voltages is sufficient to produce instant unconsciousness or to destroy the conscious nervous system. Voltage alone is not sufficient. The body can successfully function at very high voltages, as is routinely encountered in the servicing of high tension power lines. The issues at hand are not just voltage, but current flow and power dissipation (which is the product of the voltage gradient and the current density). If the voltage is applied with a small electrode, large voltage drops will occur in the immediate vicinity of the electrode, and tissue damage elsewhere will be reduced. There is no scientific evidence that a particular A.C. voltage will destroy the conscious nervous system.

29. Not only is there not a single threshold current density for stimulation of brain tissue, it appears that different measures are needed. In some cases, the quantity that determines whether a nerve is stimulated is the electric field (the voltage gradient), in others it is the gradient in the electric field, and in others it is the charge in coulombs delivered per unit area per unit time. Any discussion of the response of the brain to electrical stimulation must take these differences into consideration.

Stimulation of Nerves and Muscles

30. Because of the high current densities distributed through the skeletal muscles of the neck, thorax and leg, these muscles undergo involuntary and forceful contractions. Electrical current passing through the spinal cord and chest will stimulate the nerves enervating skeletal muscles not directly affected by the current, for example those in the arms and the leg that does not have

an electrode applied to it. These contractions are sustained, because the alternating-current shock is maintained for a long period of time. Throughout the duration of the shock, the muscles tetanize, *i.e.*, contract and remain contracted. Because both the opposing flexor and extensor muscle groups throughout the body are stimulated, the prisoner is unable to move and the entire body becomes rigid. This is consistent with the affidavits of Richard Hyde regarding the execution of Warren McClesky in Georgia in 1991 ("His body tensed up and became extremely rigid."); that of Russell F. Canan regarding the execution of John Louis Evans in Alabama in 1983 ("His body slammed against the straps holding him in the electric chair and his fists clenched permanently"); the affidavit of Johnathan Eig regarding the execution of Dalton Prejean in Louisiana in 1990 ("I saw Mr. Prejean jerk violently as soon as the executioner administrated the first jolt of electricity to his body. Mr. Prejean pressed against the straps in a futile attempt to raise from the chair. One the second or third jolt, Mr. Prejean's fist turned out."); and from press accounts of the execution of Roy Allen Harich in Florida in 1991 ("Moments later, his body convulsed, his hands gripped the chair violently, ..."); press accounts of the execution of Linwood E. Briley in Virginia in 1984 ("His fingers ... kind of tightened up almost in a fist, but in a deranged manner"); press accounts of the execution of John Arthur Spenkelink in Florida in 1979 ("His chest heaved, his right fist clenched and his left hand moved. The legs jerked."). Prior to the use of general anesthetics and muscle relaxants, a common side effect of ECT was broken bones, indicating that electrical stimulation of nerves and muscles can lead to violent muscular contractions.

31. When a 60 Hz alternating voltage is utilized in an electric chair, the nerves in the brain, spinal cord, and peripheral nervous system, as well as the skeletal muscle, will be repeatedly stimulated with each cycle of the alternating voltage, making the sensations even more painful.

32. Because the prisoner is strapped into the chair, often with arm, chest, and leg straps, the body is prevented from moving during these violent contractions of the skeletal muscles, but forces developed by the muscles are sufficient to abrade or bruise the flesh beneath the straps, (e.g., strap mark impressions on face and ankles reported in the autopsies of James William Hamblen and Jessie Joseph Tafero), or even break the straps (e.g., the affidavit of Russell F. Canan regarding the execution of John Louis Evans in Alabama in 1983).

33. When the thoracic muscles are in a state of continued contraction, the prisoner cannot breathe, nor can the prisoner cry out or provide other signs of the intense pain. In the literature on accidental electrical shock, survivors have reported that they cried out during the shock, whereas witnesses to the accident noted that the victim only produced faint sounds. The absence of sound from a prisoner during judicial electrocution is not proof that the prisoner neither experienced pain nor attempted to cry out. In fact, witnesses have stated that Jerry White screamed out when the electric current was applied during his judicial execution. This would suggest that he experienced pain. The use of a strap across the prisoner's mouth during judicial electrocution may limit the ability of the prisoner to cry out, and the maintained contraction of the thoracic musculature may prevent repeated cries, but the pain and the attempts to cry out can still occur.

34. The electric shock also causes contraction of the smooth muscles of the intestinal tract, urinary tract, and the cardiovascular system. The combined strength of the skeletal and smooth muscle contraction can be sufficient to rupture blood vessels, as indicated by prisoners who have vomited blood, or bled profusely from the eyes, nose, and mouth during execution. Vasospasm can be induced that leads to regional ischemia. In the review of autopsy reports from 40 executions by electrocution, 18 of these (45%) were reported to have blood or bloody/sanguineous froth in their lungs (Michael Lindsey, Wallace Norell Thomas, Herbert

Richardson, Nollie Martin, Herbert Lee Richardson, Nollie Lee Martin, Robert Marion Francis, Raymond Robert Clark, Anthony Bertolotti, Jessie Joseph Tafero, Jeffery Joseph Daughtery, Willie Jasper Darden, Jr., Ronald John Michael Straight, David Livingston Funchess, Michael Durocher, Larry Joe Johnson, Carl Elson Shriner, Pedro Luis Medina). One was reported to have blood in the gastrointestinal tract (Herbert Lee Richardson). Defecation, urination, and ejaculation of semen are also induced by these same strong muscular contractions.

Asphyxia and Respiratory Arrest

35. When a person receives a strong electrical shock, the electrical stimulation of the skeletal muscles required for breathing (the intercostal muscles between the ribs, the muscles of the diaphragm, and to a limited extent the muscles of the abdomen), will tetanize (contract forcibly and remain contracted), and hence the person will be unable to breathe. If the current is maintained for an adequate length of time, the person will lose consciousness due to a reduction of blood oxygen levels, and then die by asphyxiation. Since many people can hold their breath voluntarily for a minute or more without loss of consciousness, it is reasonable to assume that asphyxiation by electrocution will require a longer time.

36. The simultaneous contraction of many skeletal muscles makes a large metabolic demand on the body, and there will be a rapid decrease in blood oxygen and a corresponding increase in blood carbon dioxide. However, because the respiratory muscles are paralyzed, the prisoner cannot breathe to supply oxygen to the blood and eliminate carbon dioxide, and hence the prisoner may have a sensation of suffocation. The effect of the increased metabolic demands of the electrically stimulated skeletal muscles may shorten the duration of consciousness by an unknown amount. The massive stimulation of skeletal muscles during respiratory arrest is not a reliable means of producing rapid or painless unconsciousness.

37. Electrical stimulation of the brain can lead to respiratory arrest, another mechanism of electrical disturbance of respiration. Electrical current applied to the brain, either directly or indirectly through afferent nerve fibers, can lead to respiratory arrest. In this case, the rhythmic neural activity in the respiratory center at the base of the brain is disrupted. For strong shocks, respiratory arrest can last for minutes to hours. If artificial ventilation is maintained during respiratory arrest, then normal respiratory activity often returns. During electroconvulsive therapy, care is taken to provide mechanical ventilation of the patient should it be necessary.

38. Studies of the electroencephalogram conducted by Mikeska and Klemm during death of laboratory animals by asphyxia concluded that "If an artificially-respired, paralyzed animal is suddenly deprived of oxygen, CO_2 accumulation in the body tissues should obviously occur concomitantly with the decrease in O_2 levels. Mild increases in CO_2 in the CNS cause both behavioral and EEG arousal in cats, while high levels of CO_2 can cause anesthesia and isoelectricity in cats and rats. The long duration of EEG activation in rats rendered anoxic by the termination of artificial respiration indicates that animals killed in this manner are suffering up to the point of unconsciousness." The high metabolic demand caused by the simultaneous electrical stimulation of virtually every muscle in the body during judicial electrocution can only exacerbate this suffering.

Localized Heating of Tissues

39. The current flowing between the leg electrode and the head must pass through the knee, a region of the body that is a relatively poor conductor of electricity because of the preponderance of poorly conducting bone, tendon, fat, and ligament. Since the current must pass through this high resistance region, there will be a greater-than-average power dissipation in the knee, and as a result thermal burns would be expected. As a result, there can be substantial thermal burns well above the leg electrode. Burns centered on the posterior aspect of the knee were described

in 27 of the 40 (68%) of the autopsy reports from executions by electrocution (Horace Dunkins, Wallace Norell Thomas, Herbert Richardson, Larry Heath, Cornelius Singleton, Robert Henderson, Nollie Lee Martin, Robert Marion Francis, Robert Allen Harich, Raymond Robert Clark, James William Hamblen, Anthony Bertolotti, Aubry Adams, Jeffery Joseph Daugherty, Willie Jasper Darden, Beuaford White, Ronald John Michael Straight, David Livingston Funchess, Daniel M. Thomas, Michael Durocher, Larry Joe Johnson, Thimothy Palmes, Ernest John Dobbert, Carl Elson Shriner, Richard Lewis Adams, Anthony Antone, Robert Sullivan).

40. The neck is more muscular than the knee, but represents a geometrical constriction through which the current must flow. This will be a region of high voltage drop and power dissipation. Given the relative cross-sectional areas, the power dissipation in the neck should be high, although less than that in the scalp and lower leg. Not only does the neck contain the spinal cord, it also contains the arteries that deliver blood to the brain. Hence heating the neck will indirectly heat the brain. While the strength of the musculature in the neck would be expected to vary from individual to individual, burns and skin slippage at the neck were reported in 8 of the 40 (20%) of the autopsy reports from executions by electrocution (John Louis Evans, Arthur Lee Jones, Herbert Lee Richardson, Larry Heath, James William Hamblin, Anthony Bertolotti, Arthur F. Goode, III, Robert Sullivan).

<u>**Electrical Arcing During Judicial Electrocution**</u>

41. In electrical systems, arcing (commonly known as sparking) occurs whenever an electric voltage gradient is either large enough to ionize air, or when material vaporized by the heat resulting from the power dissipation associated with the electric current forms a conducting plasma. Once an arc is triggered, it can be difficult to extinguish. A weak electric contact between two conductors at different voltage could trigger an arc, as might saline perspiration. Arcing was reported to have occurred in the Tafero execution, apparently because of the use of a

closed-cell artificial sponge. Because of the strength of the electric current flowing through the abdomen and the leg with the electrode, there will be substantial voltage gradients along these regions. These gradients are sufficient to produce arcing across folds in the skin that occur, for example, while sitting, as were described in the autopsy reports from the executions of Nollie Lee Martin, James William Hamblen, Johnny Paul Witt, Ernest John Dobbert, and Robert A. Sullivan. Such electrical shocks and the resulting burns would be expected to be painful.

42. If a single leg electrode is utilized, one leg will carry current while the other will not. Hence there will be a large voltage drop along the current-carrying leg. However, because the other leg is not carrying significant amounts of current, it will be essentially at a constant electrical potential equal to that at the top of the thigh. While the tops of the thighs will be at the same potential, the voltage difference between the two legs will increase towards the foot. As a result, any conducting object between the legs will cause electrical current to flow from the energized leg into the unenergized one. This provides an explanation for the burns to the groin, inner thighs, scrotum or penis described in the autopsy reports from the executions of Wayne Ritter, Michael Lindsey, Herbert Richardson, Cornelius Singleton, Marvin Francois, Ernest John Dobbert, and Anthony Antone, and the smoke that arose from the feet of Warren McCleskey after the balls of his feet touched. Note that touching the balls of the feet together would be equivalent to applying a large voltage, possibly in excess of 500 volts, between the feet. Such electrical shocks and the resulting burns and stimulation of nerves and muscles would be expected to be extremely painful.

Cardiac Stimulation

43. In contrast to skeletal muscle, cardiac muscle does not tetanize with the application of the strong, rapid stimuli associated with 60 Hz a.C. current. This is because the electrical response of a cardiac cell has a duration that is comparable to the time required for the mechanical

contraction of the cell. Associated with this prolonged electrical response is a refractory period during which the cardiac cell cannot be restimulated. As a result, a cardiac muscle cell will always relax before it can be forced to contract again. In contrast, skeletal muscle has an electrical response and refractory period that are short in comparison to the time required for the mechanical response, so that repeated electrical stimuli can maintain a state of contraction.

44. Because the heart cannot tetanize, the heart may continue beating during the electrocution process, albeit with the possibility of the heartbeat being abnormal or irregular during the shock. There is a possibility that the heart will enter into a mode of excitation known as fibrillation, in which the organized, synchronized contraction of the four chambers of the heart, which normally results in the regular output of blood, is replaced by a less organized, seemingly chaotic rhythm that results in a drastic reduction in cardiac output, to the point that cardiac output is insufficient to maintain life. A heartbeat would not be heard during fibrillation. The fact that heartbeats are detected frequently after the initial round of shocks in execution by electrocution indicates that the particular direction, frequency and strength of the currents applied in execution by electrocution do not regularly induce fibrillation. This is consistent with the affidavit of Russel F. Canan regarding the execution of John Louis Evans in Alabama in 1983, in which the two doctors detected heartbeats after the first and second shocks.

45. It is a common misperception that the voltage applied by the electric chair immediately causes the heart of the prisoner to stop beating. The heart will either stop beating transiently, beat irregularly, or begin to fibrillate, and may even return to normal rhythm at the end of the shock. It is not voltage applied to the body that causes the heart to fibrillate, but <u>current</u> applied to the <u>heart</u>. Currents on the order of 100 milliamps or even less, if applied directly to the heart and at the appropriate time during the cardiac cycle, can cause ventricular fibrillation. The 2,200 to 2,350 volts a.C. applied to the prisoner will cause current to flow throughout the entire body;

the resulting current was measured in the Medina execution to have a maximum value of approximately 9 amperes. The fraction of this current passing through the heart during judicial electrocution is determined by how the electric current is distributed through the body. By applying the current between the head and both legs, the majority of this current will flow through the scalp, the muscles of the neck, the skeletal muscles of the chest and back, through the muscles and soft tissues of the abdomen, and then into the skeletal muscles of the legs. The heart is protected in part from this current by the surrounding lungs and the great vessels in the mediastinum. A small fraction of the current would be conducted into the heart through the blood vessels entering the brain, but the combined effect of the conducting scalp and the insulating skull protects these blood vessels. There is no documentation as to the actual currents applied to the prisoner's heart. The fact that a mandatory step in the execution procedure is to check for a heartbeat after the initial shock(s), and the numerous reports in the literature regarding the necessity to use multiple shocks, indicates that the currents applied to the heart through the standard electrocution procedure are typically inadequate to produce ventricular fibrillation, and the heart can continue to beat during an attempted execution.

46. The voltage gradient required to stimulate the *in vivo* human heart depends upon a variety of factors, including the uniformity of the applied electric field, the duration and timing of the stimulus, and the physiological state of the heart. A uniform electric field of 100 volts/meter applied directly to the heart may be sufficient to stimulate the heart. The voltage gradients required to trigger an abnormal reentrant rhythm of the heart, such as would be required to initiate ventricular tachycardia or fibrillation, may be at least five times as strong, *i.e.,* 500 volts/meter, and it could be stronger. It is even harder to defibrillate the heart than fibrillate it, and the defibrillation threshold also depends upon a variety of factors including the geometry of the cardiac fibers. There is no scientific basis for the assumption that the voltage

gradients in the vicinity of the heart will be of the correct strength to guarantee fibrillation of the heart. This claim is not supported by the numerous reports of a detectable heartbeat after multiple shocks during execution by electrocution.

47. It has been stated that it would take only 75/1000's (75 milliamps) of an amp of electricity to result in immediate fibrillation of the heart, resulting in loss of consciousness and death. There are several problems with this statement. The first is that because of the distributed nature of the electrical current flowing through the body during judicial electrocution, the total current delivered to the heart is unknown and hence it is unclear whether enough current is actually delivered to the heart to reliably produce fibrillation. Secondly, the threshold of the heart to electrically induced fibrillation depends upon not only the strength of the shock but also duration of the shock and the time during which it is delivered. There is no single threshold for ventricular fibrillation. Finally, there are numerous reports in the literature that indicate that during high voltage electrical accidents, the mechanism of death is not fibrillation, which is uncommon, but by asphyxia or respiratory arrest. In addition, there are studies in the scientific literature that show the probability of induction of fibrillation by AC current stimulation of sheep hearts shows a peak at 6 amps and drops steadily as the current is increased to 24 amps. These findings are consistent with there being an upper limit of vulnerability to fibrillation -- strong enough currents can cause the heart to depolarize but not fibrillate. The reports of heartbeats being detected following the prescribed course of judicial electrocution confirms that the nature of the current applied during judicial electrocution is not guaranteed to produce cardiac fibrillation and subsequent death. The average value of the strength of the current that corresponds to the upper limit of vulnerability will depend upon the exact path of the current through the heart, among other factors.

48. Just as external electrical stimulation of the brain causes great pain, studies of transthoracic stimulation of the heart have shown that the pain threshold for the thoracic muscles occurs at a lower current density than the stimulation threshold for cardiac muscle. Hence it is difficult to use externally-applied current to stimulate the heart without inducing pain.

49. Because the heartbeat is not necessarily stopped by the applied electricity, and because the voltages are typically applied for only a duration of up to two minutes, there is insufficient time for the prisoner to be asphyxiated due to the temporary paralysis of the muscles involved in respiration. Applying a shock, waiting, and applying another shock provides sufficient time for the prisoner to either gasp and introduce much-needed oxygen into the lungs, or simply relax the thoracic and abdominal muscles and allow the passive entry of air into the lungs. The heart then circulates oxygenated blood to the brain and the rest of the body, thereby keeping the subject alive for subsequent shocks. The fact that heartbeats are often detected after the initial shock is proof that this scenario indeed does occur.

50. The heart has several different rhythms. The standard rhythm is controlled by the sino-atrial node in the right atrium of the heart, and leads to the orderly contraction of the heart and the associated heart sounds and pulse. This rhythm is termed <u>sinus rhythm</u>. If the sino-atrial node is damaged or if nervous input to the sinus node reduces the sinus rate sufficiently, the slower, intrinsic rhythmicity of the other portions of the heart will pace the ventricles of the heart. In extreme cases, the ventricles can beat regularly at a rate as low as thirty beats a minute, i.e. bradycardia. This rate may not be sufficient to maintain consciousness, but it can sustain life. The heart can also beat too rapidly, *i.e.*, tachycardia, either in a regular manner or an irregular one. In some clinical conditions, the atria can be in tachycardia while the ventricles beat more slowly. In most cases, these rhythms are not life-threatening in the short term. Heart sounds and a pulse would be detectable in a tachycardia. Other cardiac rhythms include

numerous types of arrhythmias, ranging from a simple premature ventricular contraction followed by a compensatory pause (Often reported as "My heart skipped a beat.") to more complex patterns of atrial or ventricular activation, sometimes running in sets of multiple beats. Ventricular tachycardia can lead to ventricular fibrillation, a complex mode of electrical activation in the heart that does not provide for an organized contraction or pumping action of the heart, and hence neither heart sounds or a pulse would be detected. Consciousness is generally lost after fifteen to thirty seconds of ventricular fibrillation. Human hearts seldom spontaneously revert to normal rhythm after fibrillation. There is no single cardiac rhythm associated with death -- there is no uniquely identifiable "agonal pulse" or "agonal heart sound." The pulse could be weak or irregular, but this could be for a variety of reasons, including one of many non-fibrillatory arrhythmias. A pulse can be sufficiently weak or irregular that life cannot be sustained, but a heart that is producing heart sounds and a pulse is by definition pumping blood through the body. A heart that is fibrillating is not pumping blood and is not producing either heart sounds or a pulse. A heart that is producing either heart sounds or a pulse is not fibrillating. There are ample reports in the literature on judicial electrocution to indicate that fibrillation of the heart is by no means guaranteed, or even certain.

51. It is incorrect to state that an agonal pulse is incapable of pumping blood, oxygen and glucose to the brain. If the pulse can be detected, it is by definition evidence that the heart is pumping blood, oxygen and glucose to the brain.

52. The heart rhythm is maintained by a natural pacemaker in the heart, in the form of specialized cardiac tissue. The role of the autonomic nervous system is simply to modulate heart rate. The rhythm of the heart can be maintained independent of the brain: the heart can be removed from the body, severed of all nerves, and will continue to beat with a natural rhythm on its own. This is one reason that a heart can be removed from a donor and successfully

transplanted into a patient with no attempt to connect nerves. With sufficiently strong stimulation to the brain stem or vagal nerve, as can occur in electroconvulsive therapy, the heart rate can be slowed critically. However, the nature or extent of autonomic stimulation during judicial electrocution is unknown, and there is no scientific basis for assuming that the electrical stimulation of the brain will produce either bradycardia or asystole sufficient to lead to death. The reports of detectable heart sounds and pulse following attempted judicial electrocution are adequate proof that the heart can remain viable after one or more exposures to the high voltages and currents associated with judicial electrocution.

53. The fundamental issue, consistent with observations of accidental electrocution through lightning strikes, is that it may take much more than five (5) amperes or even fifteen (15) amperes of current to successfully electrocute a person. In fact, there is no data providing a definitive current threshold for death by electrocution.

54. Published studies on high voltage injuries indicate that the contact voltage in powerline injuries is usually known; however, the current and current pathways are difficult to reconstruct. Experimental studies in hogs have demonstrated limb-to-limb currents of 4 to 70 amperes when 60 hertz potentials of 2,100 to 14,400 volts rms were applied. Limb-to-limb impedances range from 130 to 477 ohms. The currents were found to depend principally upon the length of the edge of the contact. Below 1,000 volts, nonlinear current versus time and current versus voltage relationships were observed. A reduction in current occurred with arcing and skin necrosis. The observed impedance was substantially lower than the previously estimated 500 ohm value for a whole body resistance. As a result of this, a series of experiments were conducted by Sances and his coworkers to examine current pathways in high voltage injuries. They concluded that burns are routinely present with potentials in excess of 2,000 volts. The tissues are penetrated rapidly and, because of the large energies, the currents spread to adjacent parts of the tissue. The tissue

temperature rise is proportional to the square of the current flowing in each of the tissue compartments multiplied by its resistivity times the cross-sectional area, multiplied by the time of current application. It has been demonstrated that human skin requires five (5) hours for damage at a constant temperature of 44 °C (111 °F) and three (3) seconds at 60 °C (140 °F). Nerves and other organs may be more sensitive to thermal damage. Tissue destruction is thermally produced along the current pathways through the small cross-sectional body regions having a large percentage of high-resistivity bone. In the case of execution by electrocution, this occurs, for example, at the knee and in some individuals at the neck. These areas often demonstrate the greatest damage in tissue exclusive of the bone, while other larger cross-sectional body areas such as the abdominal and thoracic organs often survive direct thermal injury. Therefore, the hands, feet, and distal body segments which make contact with power lines are often destroyed. Studies with hind-limb to fore-limb current applied to hogs indicated that only 0.12% to 0.15% of the total current was carried by the spinal cord. These studies also showed that even if 10 amperes were applied, the current densities actually applied to the intestines, kidney, liver and back muscles were so low that these tissues could survive. This analysis does not include the possibility of tissue damage through vascular or biochemical alteration. The experiments on living hogs were fully consistent with measurements made by applying 2,000 volts to human cadavers one to three days after death.

Pain

55. Based on reports of individuals who have survived accidental electrocution, and those subjects who have been unsuccessfully electrocuted in the electric chair, it is clear that electrocution causes intense pain, consciousness can be maintained during electrocution, and that electrocution does not necessarily cause instantaneous unconsciousness, or instantaneous fixation of the heartbeat, or cardiac fibrillation. There is no medical or scientific evidence for

the hypothesis that execution by electrocution causes immediate brain death and that the subjects experience no pain. I conclude that most individuals who are intentionally electrocuted experience excruciating pain.

56. It is well-documented that different individuals have different thresholds for the sensation of electrical current, and the perception of pain. There are similar variations in the physiological effects of electrical currents, which are determined by neural, muscular, and geometrical factors. There will be significant individual-to-individual differences as to whether or not cardiac fibrillation is induced by the first jolt and subsequently halted by subsequent jolts, whether or not peripheral nerves and the brain are damaged by the currents, or whether respiratory arrest is maintained sufficiently long to ensure descent into unconsciousness and asphyxiation. Thus, it is absolutely unreasonable to assume that there is a single current and voltage threshold for successful execution by electrocution. The fact that multiple jolts are often required suggests that the values used are inadequate for the intended purpose.

57. If the voltage and current in judicial electrocution were sufficient to provide instantaneous cardiac arrest, it would not be necessary to maintain the current for more than thirty seconds, during which time tissue heating and burning continue. The fact that heart beats and attempted breathing have been observed following the first application of electric current during judicial electrocution, requiring the application of additional shocks, demonstrates that judicial electrocution does not produce death by the stated mechanisms. The scientific evidence would suggest that asphyxiation and excessive body temperature are more likely mechanisms.

58. There is no scientific evidence that indicates that high voltage electrocution produces rapid unconsciousness. There is no single time interval corresponding to the ability of a subject to record pain. Certain peripheral nerves in the body have conduction velocities as high as 100 meters per second, indicating that signals can be transferred in less than a single cycle of 60 Hz

electricity, even when synaptic delays are taken into account. Furthermore, with the application of electrical current to the scalp, the distances required for nerve signals to reach the brain are in fact quite short. Hence, it is scientifically incorrect to claim that the subject will perceive no pain because unconsciousness occurs so quickly. Pain is perceived most definitely in execution by electrocution, and unconsciousness does not occur instantaneously.

59. The autonomic nervous system contains large numbers of small-diameter sensory axons that are in fact difficult to stimulate electrically. However, at the levels of current density imposed during execution by electrocution, sufficient current density may be provided to stimulate many of the pain receptors and sensory neurons in the autonomic nervous system.

60. Many of the structures in the brain, such as the centers that are directly associated with receiving and processing pain signals from the body, are located deep in the cranial vault and are hence protected from the electrical current delivered directly to the head through the scalp electrode. It is unknown whether the current densities in judicial electrocution are sufficient to stimulate these pain centers directly, or to render them incapable of receiving impulses from the afferent neurons that carry pain signals.

61. It is absolutely incorrect to state that the brain does not create pain impulses, but rather pain impulses are created in the peripheral nerves. In the normally functioning person, pain impulses generally originate from the peripheral nerves, but in brain pathologies and in electrical stimulation of the brain, either during neurosurgery, accidental electrical shock, or judicial electrocution, the artificial stimulation of the neurons that would in general be the recipients of the impulses from the peripheral nerves could elicit the same response in the brain as would natural stimulation of these same neurons. As a result, the issues of delays for propagation of nerve impulses along peripheral nerves are irrelevant, since the direct stimulation of pain centers within the brain could occur as soon as the electrical current is applied.

62. It is often stated that electricity flows at the speed of light. Electromagnetic radiation such as radio waves, microwaves, and infrared radiation are light, and propagate at the speed of light, but electric current flow in biological tissue is due to the motion of ions, which have inertia and move at much lower velocities. The rate at which a voltage can be applied to the body is determined not by the speed of light, but by the electrical resistivity and electrical capacitance of the body and its internal tissues — charge must be delivered to the body to raise its electrical potential, and the ability of this charge to move is determined by the resistivity. The amount of charge required to change the potential is determined by the capacitance.

63. In the case of nerves, the substantial capacitance of the membrane and the resistivity of the axoplasm sets the maximum velocity by which passive electrical voltages will appear along the nerve. In nerves, passive (termed electrotonic) signals propagate quickly but only over distances of several millimeters to centimeters; propagating action potentials are required to convey information over longer distances. It is clear that if nerves are placed in a sufficiently strong electric field, they can be depolarized electrotonically over much of their length more quickly than can be accomplished by a propagating impulse, but the electrotonic velocity, if one can be defined, is far far less than the speed of light. It is not correct to argue that electrocution occurs at the speed of light and hence outruns nerve signals. A neuron in the brain that is directly stimulated by the electric current flowing through the brain need not wait for an action potential to arrive from a distant part of the body and report that another part of the body has also been stimulated. Since pain sensations can be created directly within the brain, the time required for pain impulses to arrive via afferent neurons is irrelevant.

64. It is incorrect to assume that the human brain and peripheral nerves cannot respond to the rapid reversals of the electric field associated with 60 Hz electrical shocks. For many nerves, the threshold for perception of electrical stimulation peaks in the vicinity of 60 Hz, but neurons are

capable of responding to much higher frequencies. The nerves in the human ear can respond to 20,000 stimuli per second, neurons in the brain have been recorded producing more than 1000 spikes per second. Responses to stimulation have been observed at rates as high as 2,400 pulses per second, forty times that provided by judicial electrocution. Victims of accidental electrical shock recount the perception of each cycle of electrical current. Others report darkening of the visual field, loss of hearing, distorted feelings such as the swelling of the head and the shrinking of the body to unrealistic dimensions. Hence it is reasonable to conclude that some neurons in the brain will be sequentially depolarized and repolarized by the alternating electrical current used in judicial electrocutions. There is no scientific basis to assume that all neurons will be depolarized and will be thereafter incapable of repolarizing during alternating current stimulation.

Given the ability of neurons to respond to high frequency stimuli, it is reasonable to assume that the brain is capable of processing pain sensations, arising either from peripheral nerves or from direct stimulation of the brain, until such time as the prisoner loses consciousness due to asphyxia, cardiac fibrillation, or electrically induced grand mal seizures of the brain.

65. Comparisons are often made between the stimulation of the brain resulting from the electrical current delivered during judicial electrocution and that utilized in the operating room during neurosurgical procedures. The comparison of the 9 amperes delivered to the head during judicial electrocution and the 1 to 15 milliamperes delivered during neurosurgery has been used to suggest that judicial electrocution produces effects that are much stronger. This is a fallacious argument, in that a current through the entire head is being compared to the current delivered by an electrode with a diameter of a millimeter or so. Suppose that 10 percent of the current from the judicial electrocution crosses the skull and enters the brain. If the brain is 12 cm in diameter, then the cross-sectional area through which this current flows is 113 cm^2. The current density is

thus 0.9 amperes divided by 113 centimeters, or 0.008 amperes per square centimeter. In contrast, the 1 to 15 milliamperes delivered by a neurologist's stimulating electrode produces a current density ranging from 1 to 15 milliamperes divided by 0.01 cm^2, or 0.1 to 1.5 amperes per square centimeter. The current densities regularly used stimulate the brain in neurosurgical procedures or for chronic stimulation of brain tissue are ten to two-hundred times stronger than those delivered during judicial electrocution. Hence claims that the currents used in judicial electrocution are so strong as to render the brain unconscious are unfounded.

66. As a result of this analysis, I conclude that there is no scientific basis for the claim that execution by electrocution produces instantaneous and massive depolarization within milliseconds of the initial surge of electricity into the head of the prisoner and that the heart goes into instant fibrillation, all of which cause the prisoner to lose consciousness and die within 34 seconds of the initial jolt of electricity without suffering conscious pain. To the contrary, there is substantial scientific literature that indicates that the brain is capable of perceiving pain at least during the initial stages of electrocution, that cardiac fibrillation does not occur, and that the prisoner dies of asphyxiation and heating.

I declare under penalty of perjury and the laws of the United State that the foregoing statements are true and correct.

John P. Wikswo, Jr., Ph.D.

18 OCT 2006
Date

APPENDIX A
SUMMARY OF SELECTED MATERIALS REVIEWED BY JOHN WIKSWO
October 18, 2006

(1) AUTOPSY OF JOHN LOUIS EVANS

5'8.5" 170-180 lbs Normally developed

Numerous thermal injuries to the head and neck region; burns through to the subcutaneous fat; skin slippage in these areas; darkening of the underlying dural layers; burning of skeletal muscle in these areas (Page 2)

Thermal injuries on legs, and compression contusions on legs; burns through to underlying skin and tendons on legs; hyperemia; charring colored black-brown in this region; skin slippage in these areas; burning of subcutaneous fat; brain endematous (1500 gm) (Pages 3-4)

(2) AUTOPSY OF ARTHUR LEE JONES

5'1" 158 lbsNormally developed

Numerous thermal injuries and burning of skin in head region, skin slippage in these regions (Page 2)

Skin slippage on neck; skin slippage and hyperemia on leg (Page 3)

Thermal injuries on upper back; bones of calvarium intact; brain sectioning normal except for edema (1240 gm); bones at base of skull intact; skin slippage on neck; no fluid in lungs (Page 4)

Liver, pancreas, and spleen congested (Page 5)

Pathological diagnosis of high voltage electrical injury, cerebral edema, diffuse visceral congestion (Page 6)

(3) AUTOPSY OF WAYNE EUGENE RITTER

72" 177 lbs Normally developed

Band-like burn to head; numerous burns to head, neck, ears and abdomen, with hyperemia and skin slippage (Page 2)

Burns on scrotum and leg; brain warm and edemous (1610 gm), with swelling of gyri and compression of sulci, parboiled appearance; subcutaneous tissues congested; mesothelial surfaces congested; neck parboiled appearance (Page 3)

Pancreas and kidneys congested (Page 4)

Pathological diagnosis of electrocution with multiple electrical burns and passive congestion of all viscera (Page 5)

(4) AUTOPSY OF MICHAEL LINDSEY

76" 232 lbs

Band-like burns around head with skin slippage (Page 1)

Burns to scrotum and leg; pathological diagnosis of electrocution with contact burn on head, exit mark on left leg, arcing in groin, pulmonary edema and congestion, acute passive congestion of viscera, cerebral edema; Brain edematous (1410 gm) (Page 2)

Frothy, blood-tinged fluid in bronchial tree; lungs and pancreas acutely congested (Page 3)

(5) AUTOPSY OF HORACE DUNKINS

70" 177 lbs

Burns on scalp, lower back, buttocks, left hip, left knee, thighs and shoulder, all with blistering and charring; abrasion on chest; dried bloody material on right corner of mouth (Page 1)

Pathological diagnosis of numerous electrical burns and severe pulmonary congestion and edema (Page 2)

Frothy hemolytic fluid filling the bronchi; lungs severely endematous and congested; burns on head include severe charring (Page 3)

(6) AUTOPSY OF WALLACE NORELL THOMAS

74" 188 lbsNormally developed, muscular

Numerous burns to head region including burning through dermis and epidermis to subcutaneous fat, blanching and skin slippage; charring; "a dark brown parchment-like alteration of the epidermis, dermis and subcutaneous tissue" (Page 2)

V-shaped current mark on the neck; current mark (burn) to the abdomen with charring, burns to the thighs and legs with charring; burn on knee deep into subcutaneous fat (Page 3)

Hyperemia of scalp, charring of underlying muscle, bones of skull intact, edematous brain (1500 gm), leptomeningeal vessels congested, brain sectioning normal, airways congested with frothy, blood-tinged fluid, all tissues markedly congested (Page 4)

Liver, pancreas, kidneys congested (Page 5)

Pathological diagnosis of numerous burns throughout body, pulmonary edema and cerebral edema severe, diffuse visceral congestion (Page 6)

(7) AUTOPSY OF HERBERT RICHARDSON

68" 148 lbsNormally developed, average build and nutritional status

Body exceptionally warm to touch; blistered black and charred lesion on scalp and ear; mid portion of ear blackened, hardened and contracted; hat-ring burn (Page 2)

Burns and blackening on posterior neck and scalp with underlying change in dermis; burns and blisters around ears; blackened charring near ear; burns on trunk; burns and charring on scrotum and thighs (Page 3)

Left knee and leg burns with parchment-like changes in underlying tissue; blisters in area; skin slippage; contraction of left knee; muscles of scalp light pale; calvarium and skull intact; brain weight 1400 gm (Page 4)

Markedly hemoragic mastoid air sinuses; pulmonary tissue expanded and congested and exude abundant amounts of serosanguinous fluid (Page 5)

Sanginuous mucus in stomach; pulmonary edema and pulmonary capillary congestion; intraaviolar hemorrage (Page 6)

Epidermis on left leg missing (Page 7)

Diagnosis of electrical burns (Page 8)

(8) AUTOPSY OF LARRY HEATH

71" 224 lbs

Diagnosis of electrical burns to scalp, thigh, left leg, great toes; petechial hemorrhages of left conjunctiva, neck and chest hands and legs; contusion base of neck; abrasion right leg; contusion of pharynx (Page 1)

Circular burn on scalp; burns on thighs and left leg; dark-brown charred burn of the big toes; petechial hemorrhages of conjunctiva, neck and chest; burn around left knee; petechial hemorrhages on right hand (Page 2)

Pulmonary edema; pancreas congested; duodenal mucous congested (Page 3)

Meninges clear; yellow and brown burn on scalp; peeling of skin extending to left ear; petechiae on right hand (Page 4)

(9) AUTOPSY OF CORNELIUS SINGLETON

72" 156 lbs

Electrical burns of head and left leg (Page 1)

Circular burn region on head; circumferential burn on left knee; burns of inner thigh and genitalia (Page 2)

Sectioning of brain normal (Page 3)

Microscopic examination of brain, heart, and organs reveals no abnormalities (Page 4)

(10) AUTOPSY OF ROBERT HENDERSON

70" Well developed well nourished

Burn ring on scalp and circumferential burn on right leg and knee, with skin slippage (Page 1)

Full thickness burn of scalp; calvarium and base of skull intact; brick-red clot in epidural area overlying sagittal sinus; meningeal vessels congested; brain 1450 gm, burns noted (Page 3)

(11) AUTOPSY OF NOLLIE LEE MARTIN

73" Well developed well nourished

Burn ring on head with charring and erythema of scalp; incompletely circumferential burn of right leg at and below knee; burns on thigh and trunk (Page 1)

Full thickness burn on scalp; brick-red clot over sagittal sinus; clot is granual; multiple cuts of brain reveal no abnormalities; brain 1330 gm (Page 2)

Cardiac chambers with clotted and unclotted blood; pulmonary congestion and edema; lungs ooze bloody, foamy substance (Page 3)

Findings of numerous burns, pulmonary edema and congestion (Page 4)

(12) AUTOPSY OF ROBERT MARION FRANCIS

71" Well developed well nourished

Body has residual warmth; right knee with heat fixation; burn ring on scalp and burn on right leg at knee; full thickness burn on leg through subcutaneous tissue; underlying skeletal muscle on knee is discolored gray-tan; dura over sagittal suture discolored brown (Page 1)

Meningeal vessels congested; lung surfaces congested oozing dark red blood (Page 2)

Findings of burns and pulmonary congestion (Page 3)

(13) AUTOPSY OF ROY ALLEN HARICH

71" Well developed well nourished

Burn annulus on scalp; circumferential burn on right knee; burns have gray to brown char, and extend full thickness into subcutaneous fat, with erythema; calvarium and skull base intact; dura has a thin red-brown hematoma over sagittal sinus; meningeal vessels congested (Page 1)

Cardiac chambers with clotted and unclotted blood; lungs congested (Page 2)

Findings of burns, epidural hematoma and pulmonary congestion (Page 3)

(14) AUTOPSY OF RAYMOND ROBERT CLARK

71" Well developed well nourished

Scalp and right knee burns; skull cap and base intact; meningeal vessels congested; no brain abnormalities; extensive adhesions about right lung; brain weight 1490 gm (Page 1)

Lungs increased in firmness and ooze blood (Page 2)

Findings of electrical burns (Page 3)

(15) AUTOPSY OF JAMES WILLIAM HAMBLEN

68" Well developed well nourished slender

Scalp burn ring with purple discoloration; right knee burn with heat fixation; strap mark impressions on face and ankles; skin slippage of eyelids & neck (Page 1)

Skeletal muscle on head discolored to tan; brain increased in firmness (1350 gm) (Page 2)

Lungs mildly congested (Page 3) Findings of burns, cerebral epidural hematoma (Page 4)

Burns to groin

(16) AUTOPSY OF ANTHONY BERTOLOTTI

64.5" Well developed well nourished

Burn annulus and numerous other burns on head and on leg, with brown to black discoloration; belt-like abrasions at right hip; skin slippage near burns and underlying tissues increased in firmness; skull and calvarium intact; brown discoloration of dura mater (Page 1)

Cuts through brain reveal no abnormalities; lungs congested with blood oozing from sectioned surfaces (Page 2)

Findings of numerous burns on head, leg at knee, and neck, abrasions and pulmonary congestion (Page 4)

(17) AUTOPSY OF JESSE JOSEPH TAFERO

70" Well developed well nourished slender

Burn of scalp and right leg; blunt force injuries to hands; eyebrows and eyelashes singed (Page 1)

Scalp burn extends full thickness; cuts through brain reveal no abnormalities; lungs congested and blood oozes from sectioned surfaces (Page 2)

Findings of burns to scalp and leg, lacerations to hands, strap marks, and pulmonary congestion (Page 3)

(18) AUTOPSY OF AUBREY ADAMS

69" Well developed well nourished

Burn ring on scalp; burn on right leg; within scalp ring, scalp is dark-grayish purple; ring itself is tan and has skin slippage; skin slippage, increased firmness and gray-tan discoloration to burn on the leg (Page 1)

Dark red-brown discoloration to the dura mater overlying the sagital sinus and immediately beneath the center of the scalp burn ring; lung surfaces increased in firmness and decreased in crepitance (Page 2)

Findings of head and leg burns and pulmonary congestion (Page 3)

(19) AUTOPSY OF THEODORE ROBERT BUNDY

71" Well developed well nourished slender

Burn ring on head; burn on right leg below knee; yellow-tan discoloration of skin on head with skin slippage; salt deposits on scalp; skin slippage on leg burn with yellow-tan discoloration (Page 1)

Calvarium and skull base intact; brown-red discoloration in dura overlying brain; cuts of brain reveal no abnormalities; lung substance crepitant and light pink (Page 2)

Findings of electrical burns to scalp and leg (Page 3)

(20) AUTOPSY OF JEFFREY JOSEPH DAUGHERTY

71" mildly obese

Burn annulus on head; scalp dark brown to tan and firm; outer regions of annulus reddish-pink; burn on right leg at knee; yellow-brown discoloration of leg burn (Page 1)

Lungs increased in firmness and decreased in crepitance; blood oozes from congested sectioned surfaces of lung (Page 2)

Calvarium and skull base intact; dura overlying brain discolored light tan to brown; cuts through brain reveal no abnormalities (Page 3)

Findings of head and leg burns and pulmonary congestion (Page 4)

(21) AUTOPSY OF WILLIE JASPER DARDEN, JR.

71"   Well developed well nourished

Burn to leg at knee and burn ring on head; burns with dark brown to black discoloration and increased ion firmness of surrounding tissues; calvarium and skull intact; brown-gray discoloration of dura mater; brain warmer than rest of body; cuts through brain reveal no abnormalities (Page 1)

Lungs congested; blood oozes from sections of lung (Page 2)

Findings of burns and pulmonary congestion (Page 3)

(22) AUTOPSY OF BEAUFORD WHITE

65.5"   Well developed muscular

Burn annulus; leg burn; burn margins blackened and quite firm; skin slippage; burn below clavicle; burn seen on the shirt; calvarium and skull intact; heat epidural hematoma beneath sagittal sinus; heat fixation over cerebral convexities (Page 1)

Pulmonary regions increased in firmness and decreased in crepitance (Page 2)

Findings of burns, heat epidural hematoma, pulmonary congestion (Page 3)

(23) AUTOPSY OF RONALD STRAIGHT

71"   Slender

Burn ring on head; burn on leg; burnt tissues are quite firm, gray-brown with skin slippage and erythema; extradural blood accumulation on head; leptomeningeal vessels congested (Page 1)

Brain reveals no other abnormalities; lung substance increased in firmness and decreased in crepitance; lung sections ooze pink fluid (Page 2)

Findings of burns and pulmonary congestion and edema (Page 3)

(24) AUTOPSY OF DAVID LIVINGSTON FUNCHESS

72"   Well developed well nourished muscular and slender

Burn annulus on head; burn to leg at knee; leg burn is black, full thickness, and quite firm; calvarium and base of skull intact; heat epidural hematoma beneath sagittal suture (Page 1)

Leptomeningeal vessels congested; no other brain abnormalities; lung substance increased in firmness and decreased in crepitance; sectioned lung oozes sanguineous fluid (Page 2)

Findings of burns and pulmonary congestion (Page 3)

(25) AUTOPSY OF DANIEL M. THOMAS

73"   Well developed slender and muscular

Burn halo on head; burn on leg at knee; burn halo with blackened margins; salt rivulets on head; leg burn with blackened margins; configuration of burn halo on outer table of calvarium; brick red heat-fixed blood in cerebral epidural surface; superior cerebral surfaces discolored tan to brown (Page 1)

Brain tissue softer farther from burn mark (Page 2)

Findings of burns and epidural hematomas (Page 3)

(26) AFFIDAVIT OF RICHARD HYDE

RE Execution of Warren McClesky in Georgia in 1991

McCleskey's body tensed up and became extremely rigid; the balls of his feet touched and smoke rose from feet; body remained rigid while electricity was applied to body (Page 2)

(27) AFFIDAVIT OF RUSSELL F. CANAN

RE Execution of John Louis Evans in Alabama in 1981

First 30-second jolt applied; sparks and flames from electrode on leg; body slammed against straps; fist clenched permanently; smoke and sparks from hood; stench of burning flesh

Two doctors examined and not dead; leg electrode strap had apparently burst; second jolt and more stench of burning flesh; smoke from head and leg (Page 1)

Doctors examined him and still alive. Third jolt. Declared dead.

(28) AFFIDAVIT OF SAMUEL GLASSCOCK

RE Execution of Frank J. Copolla in Virginia in 1982

Two 55 second applications of current

During second application, smoke from head and leg; flames from leg; sizzling sound; smoke rising to the ceiling; smell of burning flesh (Page 1)

(29) AFFIDAVIT OF JONATHAN EIG

RE Execution of Dalton Prejean in Louisiana in 1990

Four jolts of electricity: 2000 V 10 s, 500 V 20 s, 2000 V 10 s, 500 V 20 s.

I saw Mr. Prejean jerk violently as soon as the executioner administrated the first jolt of electricity to his body. Mr. Prejean pressed against the straps in a futile attempt to raise from the chair. One the second or third jolt, Mr. Prejean's fist turned out.

On the third jolt, spark from left leg and smoke from the leg (Page 2)

Lips blue when mask removed.

(30) AFFIDAVIT OF JOHNNY ROBINSON

RE Execution of Alvin Moore in Louisiana in 1987

Third degree burns on head and leg; epidermis missing on head

(31) "Killer Goes Casually To Chair"

RE Execution of James William Hamblin in Florida in 1990

Frail looking

White smoke rose from head and leg; acrid odor filled the air (Page 2)

(32) "Smoke, Flames Erupt As Killer Is Executed"

RE Execution of Jessie Tafero in Florida in 1990

Flames and smoke from head set; continued to breath and slowly nod his head after first and second shocks; each time they turned on the switch, flames shot out and smoke rose from underneath mask

2000 V and 14 amps

(33) "Execution Keeps Death Penalty Opponents Focused On Virginia"

RE Execution of Willie Leroy Jones in Virginia in 1992

Body jerked slightly upon application of electricity; fists clenched; smoke and sparks from right leg (Page 1)

(34) "Confessed Double Murderer Executed"

RE Execution of Willie Leroy Jones in Virginia in 1992

Wisps of smoke rising from chair after switch flipped (Page 1)

There was a lot of smoke

(35) "Victim's Sister Sees Execution"

RE Execution of Roy Allen Harich in Florida in 1991

Moments later, his body convulsed, his hands gripped the chair violently, and a puff of smoke rose from the electrodes on right leg (Page 1)

(36) "Clark Executed in Florida"

RE Execution of Robert Raymond Clark in Florida in 1990

Only visible sign was smoke rising from leg which jerked when electricity applied (Page 1)

(37) "Execution Takes Three Tries; Witnesses Shaken"

RE Execution of William Vandiver in Indiana in 1985

Three jolts of electricity; breathing ceased but heartbeat remained regular; final application of 2300 V for 5 s and 500 V for 25 s.

A lot of smoke coming from head; tremendous smell of burning, he was breathing, you could hear him breathing.

(38) "Sorrowful, Satisfied Crowds Greet Briley Execution"

RE Execution of Linwood E. Briley in Virginia in 1984

Two jolts of 2500 volts; "his fingers ... kind of tightened up almost in a fist, but in a deranged manner" (Page 3)

Odor of burned flesh; a little smoke from his right leg (Page 4)

(39) "Convicted Murderer Executed By Florida"

RE Execution of John Arthur Spenkelink in Florida in 1979

With the first jolt, "His chest heaved, his right fist clenched and his left hand moved. The legs jerked. The flesh on leg seared; smoke rose into chamber; three inch wound below electrode; skin had split but no blood; smell of burning flesh did not reach official witnesses; hands turned blue, especially near the fingertips; first jolt did not kill him; second jolt applied; examined again; third jolt applied; declared dead

(40) "Confesses To Another Crime"

RE Execution of Julius Morgan in Tennessee in 1916

Two jolts; "The second shock was given to make sure of his instant death and to relieve him of any possible pain that might come from burns (Page 2)

(41) AUTOPSY OF MICHAEL DUROCHER

74" Well developed slender

Electrical burns on scalp and right leg; burn ring; skin slippage and erythematous change around area; calvarium intact; brain 1660 gm; heat epidural hematoma beneath sagittal suture; reddish-brown discoloration outer surface of dura mater; brain substance warm; gyri flattened; sulci narrowed; no other brain abnormalities (Page 1)

Heart distended with unclotted blood; lung substance increased in firmness and decreased in crepitance; dark red blood oozes from sectioned lung; lymph nodes of mediastinum enlarged and anthracotic; lymph nodes about pancreas and liver mildly enlarged (Page 2)

Burn on leg at knee; tan to brown color around burn; firm consistency of burn; erythematous rim around burn; skin slippage; findings of burns on scalp and leg and pulmonary congestion and edema (Page 3)

(42) AUTOPSY OF LARRY JOE JOHNSON

67" Well developed well nourished

Burn ring on scalp; erythematous rim on tissue; skin slippage; tan to brown discoloration with heat fixation; calvarium and skull intact; heat epidural hematoma; underlying dura gray-tan discoloration; cuts through brain reveal no abnormalities (Page 1)

Lung substance moderately congested and frothy fluid oozes from sectioned lung; liver congested (Page 2)

Burn on right leg at knee (Page 3)

Findings of burn ring; burn on right leg; heat epidural hematoma; pulmonary congestion and edema; cardiomegaly (Page 4)

(43) AUTOPSY OF MARVIN FRANCOIS

71.75"　　Well developed well nourished

Annular burn on scalp; burn on right leg below knee; pleural pericardial spaces reveal adhesions; cardiac chambers dilated with clotted and unclotted blood; lung substance increased in firmness and subcrepitant; sectioned surfaces congested (Page 1)

Scalp burns; calvarium and skull intact; heat epidural hematoma not present; dural and leptomeningial vessels congested and firm; gyri widened; sulci narrowed; cuts through brain reveal no other abnormalities; findings of electrical burns, pulmonary congestion and acute cardiac dilation (Page 2)

(44) AUTOPSY OF JOHNNY PAUL WITT

70"　　Well developed well nourished

Annular burn on scalp; skin slippage; burn on leg at knee; variation from slight erythema at periphery to focal tan to brown firm tissue fixation; burns in groin area with yellow-tan centers and erythematous rings (Page 1)

Cardiac chambers dilated with clotted and unclotted blood; pulmonary parenchyma subcrepitant; pleural anthracotic pigment deposit and enlarged lymph nodes of pulmonary hila and mediastinum; full thickness burn of scalp; epidural hematoma above sagittal suture; blood clot firm and brick-red; dura not adherent to clot and discolored slightly brown (Page 2)

Upper cervical spinal cord multiple minute petechiae (Page 3)

Findings of burns of scalp, groin, and right leg finding of epidural hematoma (Page 4)

(45) AUTOPSY OF JAMES DAVID RAULERSON

68" Well developed well nourished

Annular burn on head; burn on leg; heart dilated with clotted and unclotted blood; lungs increased in firmness and subcrepitant; sectioned surfaces are congested (Page 1)

Calvarium and base of skull intact; dural and leptomeningeal vessels congested and firm; gyri widened and sulci narrowed on cerebral hemisphere; findings of electrical burns, pulmonary congestion and acute cardiac dilation (Page 2)

(46) AUTOPSY OF TIMOTHY PALMES

71" Well developed adequately nourished

Annular burn on scalp; burn on right leg at knee; heart chambers distended with unclotted blood (Page 1)

Full thickness burn of scalp; calvarium and skull intact; dura over cerebral hemispheres covered with red-brown hematoma; cuts through brain reveal no other abnormalities; findings of burns to scalp and leg, epidural heat hematoma, pulmonary congestion and splenomegaly with congestion (Page 2)

(47) AUTOPSY OF JAMES DUPREE HENRY

68" Well developed somewhat muscular and slender

Incomplete annular burn with char on right leg; annular burn of scalp; thickness of burn 1 to 1.5 inches; skin slippage (Page 1)

Scalp burn; calvarium and base of skull intact; dura over cerebral areas discolored brown with brittleness of membrane; flattening of gyri and narrowing of sulci over parietal lobes; cuts of brain reveal no other abnormalities; finding of annular burn of scalp (Page 2)

(48) AUTOPSY OF ERNEST JOHN DOBBERT

74" Well developed well nourished

Annular burns to top of head; burns on lower abdomen, thigh, scrotum, and leg (Page 1)

Cardiac chambers dilated with clotted and unclotted blood; lungs increased in firmness and subcrepitant; sectioned surfaces congested; calvarium and base of skull intact; dural and leptomeningeal vessels congested and firm; gyri widened and sulci narrowed in superior aspect of brain; cuts through brain reveal no other abnormalities; brain 1390 gm (Page 2)

Findings of burns of scalp abdomen, groin, and leg; pulmonary congestion and acute cardiac dilation (Page 3)

(49) AUTOPSY OF DAVID WASHINGTON

72" Well developed well nourished slender and muscular

Annular burn of head with brown discoloration skin slippage and increased firmness; whitish granular precipitate on scalp; burn on right leg with skin slippage and charring; burn on right heel (Page 1)

Calvarium and base of skull intact; dura underlying burn discolored brown with increased firmness; gyral flattening and sulcal narrowing; cuts through brain reveal no other abnormalities; findings of burns to scalp, leg, and right heel (Page 2)

(50) AUTOPSY OF CARL ELSON SHRINER

71" Well developed adequately nourished

Annular burn of scalp with skin slippage and red-tan heat alteration of scalp tissue; burn on leg; lung surface increased in firmness; sanguineous fluid oozes from sectioned lung surfaces (Page 1)

Full thickness scalp burn; calvarium and base of skull intact; epidural hematoma; underlying superior aspect of cerebral hemispheres increased in firmness and pallor; other cuts through brain reveal no more abnormalities; Findings of burns, epidural hematoma; pulmonary congestion (Page 3)

(51) AUTOPSY OF RICHARD LEWIS ADAMS

70" Well developed muscular

Annular burn on head; burn on leg at knee; cardiac chambers dilated with unclotted blood (Page 1)

Burn on scalp yellow-brown discoloration; sagittal sinus discolored brown; dura has prominent vessels; leptomeningeal vessels congested and prominent; cuts through brain reveal no other abnormalities; brain 1440 gm (Page 2)

Findings of burn of scalp and leg (Page 3)

(52) AUTOPSY OF ARTHUR F. GOODE, III

67" Well developed well nourished

Annular burn to scalp; burn on right leg at knee; punctate burn to right side of neck; anthracotic pigmentation on visceral surfaces of lungs; sectioned surfaces of lungs red-brown in color; lung substance subcrepitant (Page 1)

Calvarium and base of skull intact; epidural hematoma; underlying dura discolored grey-brown; gyri flattened and sulci narrowed; dark red blood in subarachnoid spaces underlying hematoma; brain stem warmer than surface of hemispheres (Page 2)

Findings of burns of scalp, leg, and neck, and epidural hematoma (Page 3)

(53) AUTOPSY OF ANTHONY ANTONE

67"

No autopsy, but drawings of injuries. Annular burn to scalp, electrical burn in groin, and burn at knee.

(54) AUTOPSY OF ROBERT A. SULLIVAN

71" Mildly obese

Annular burn on head and forehead; skin in zone is tan to brown and quite firm; conjunctival vessels injected; skin of forehead has violaceous lividity; burn on neck near ear; two burns on thighs; burns on leg (Page 1)

Calvarium intact; 4 x 2 subdural hematoma red-brown; brain 1600 gm (Page 2)

Findings of multiple burns and epidural hematoma (Page 3)

Linear electrical burn in groin